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**Allen et al.**

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(54) **MODULAR OPTICAL FIBER SPLICE TRAY SYSTEM**

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**G02B 6/255** (2006.01)  
**G02B 6/46** (2006.01)

(52) **U.S. Cl.**  
CPC ..... **G02B 6/4454** (2013.01); **G02B 6/2551** (2013.01); **G02B 6/4446** (2013.01); **G02B 6/4471** (2013.01); **G02B 6/46** (2013.01)

(58) **Field of Classification Search**  
CPC ..... G02B 6/4453  
See application file for complete search history.

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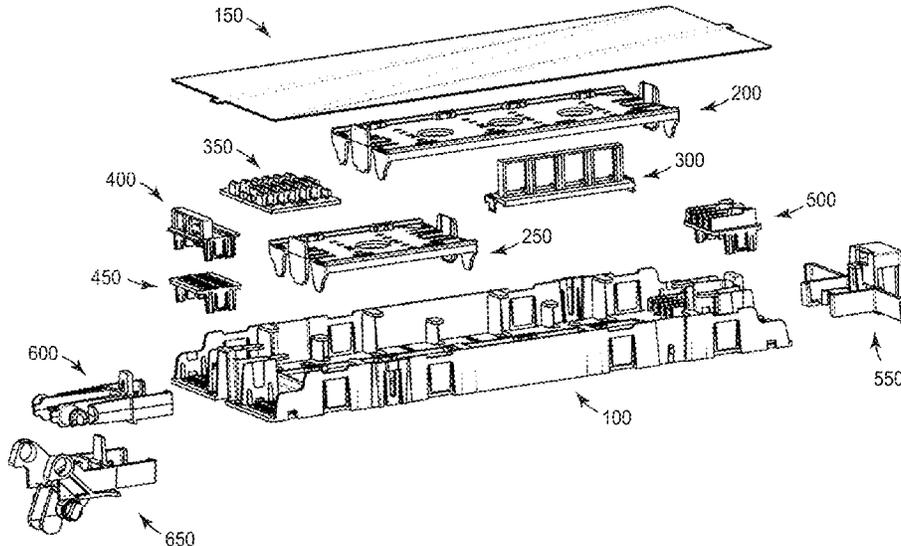
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(57) **ABSTRACT**

The present description relates to a modular, reconfigurable splice tray system that comprises a splice tray having a base extending longitudinally from a first end to a second end, a pair of side walls extending longitudinally between the first and second ends of the base, a plurality of cable entrances formed at the first and second end of the base and a receiving portion configured to receive a modular component disposed between the cable entrances at the first end and at the second end.

**19 Claims, 25 Drawing Sheets**



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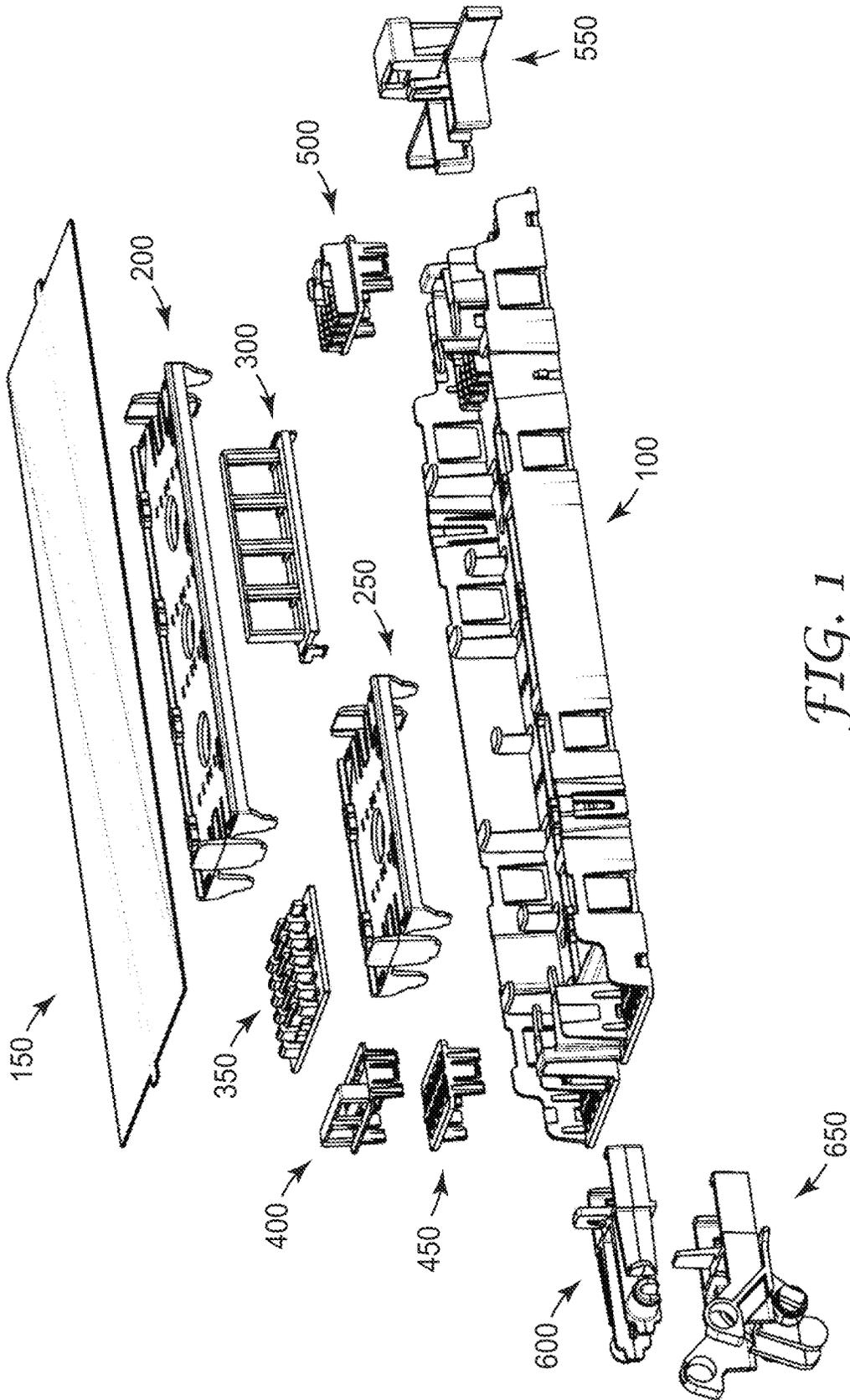


FIG. 1

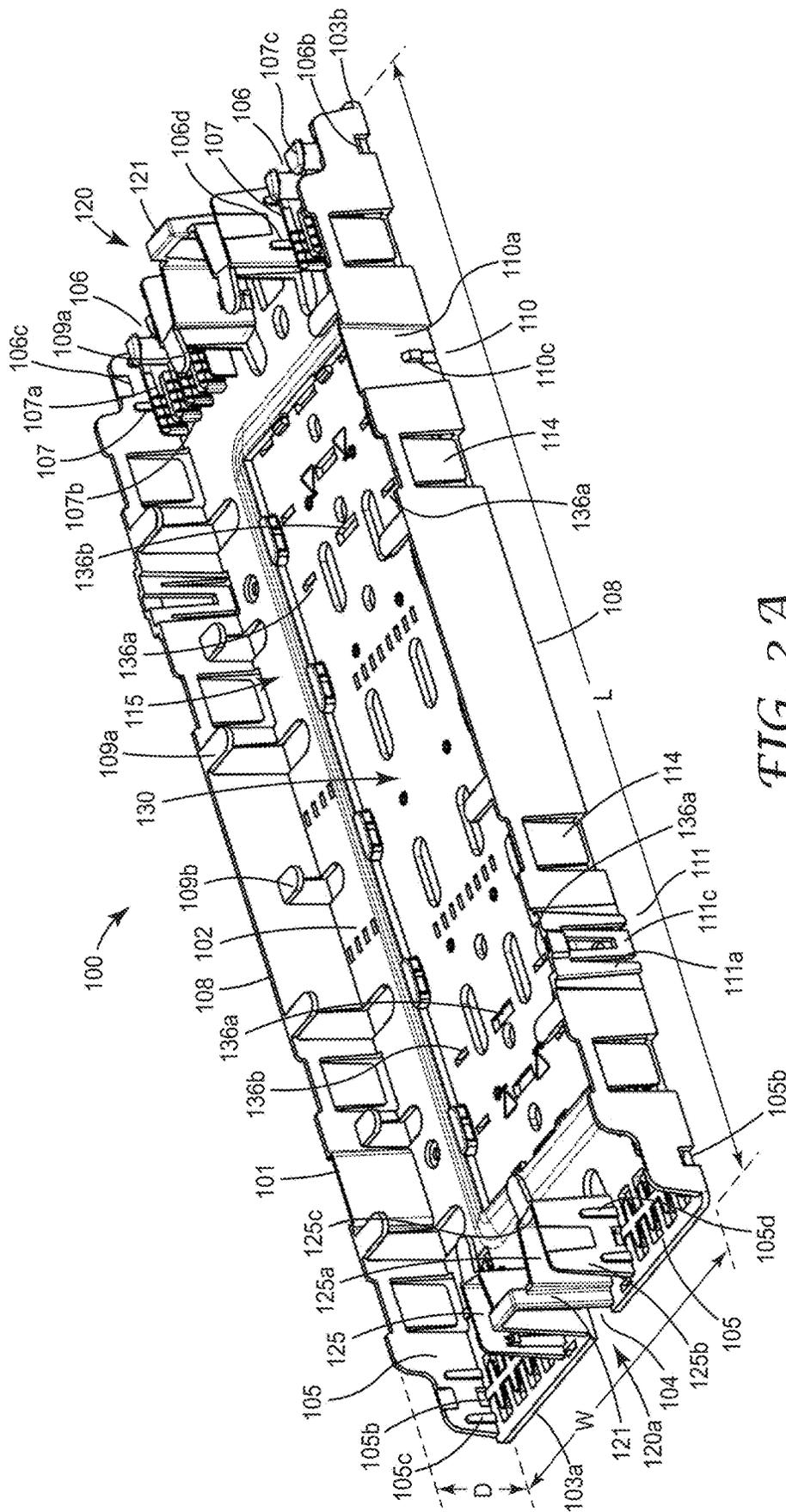


FIG. 2A



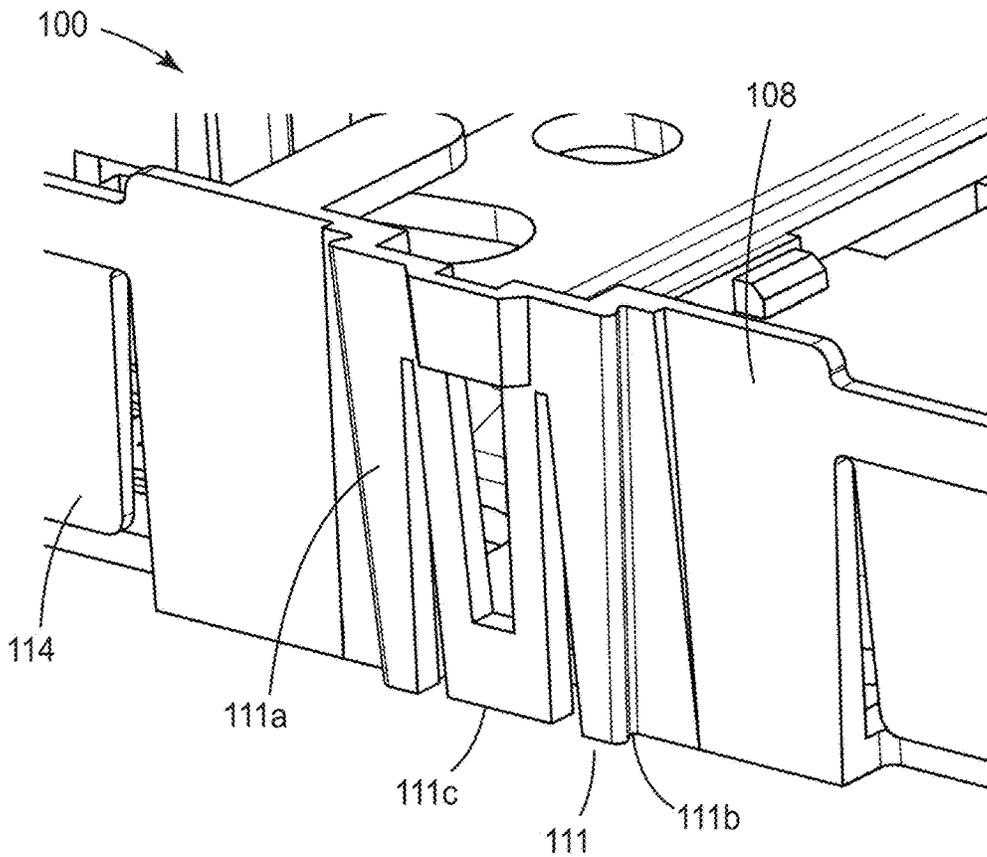


FIG. 3A

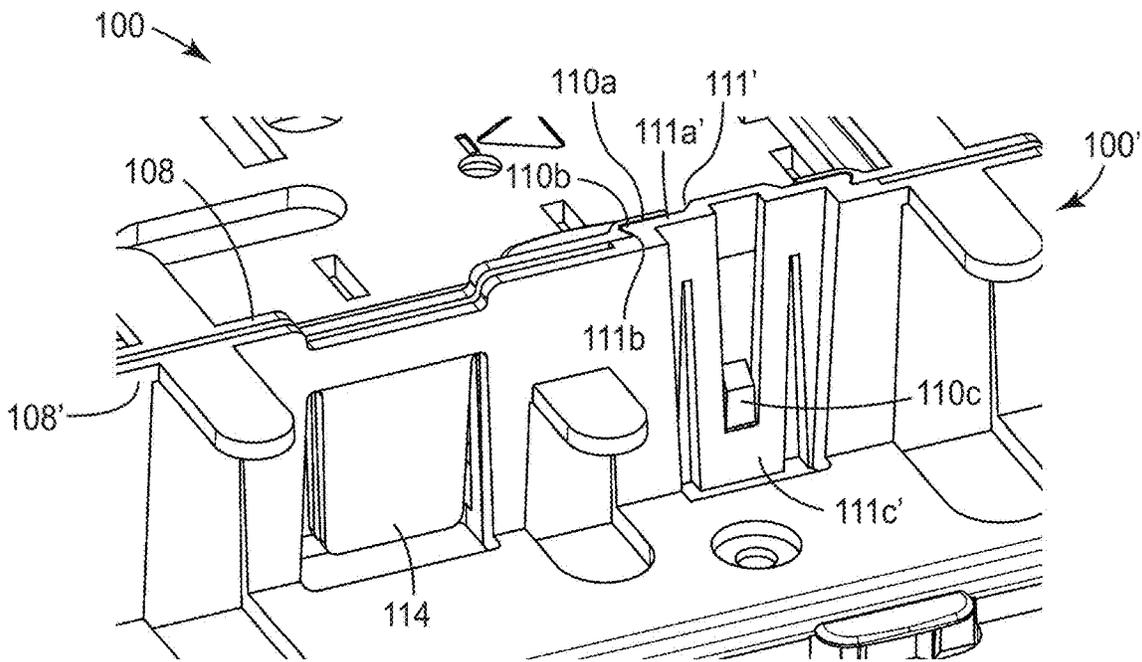


FIG. 3B

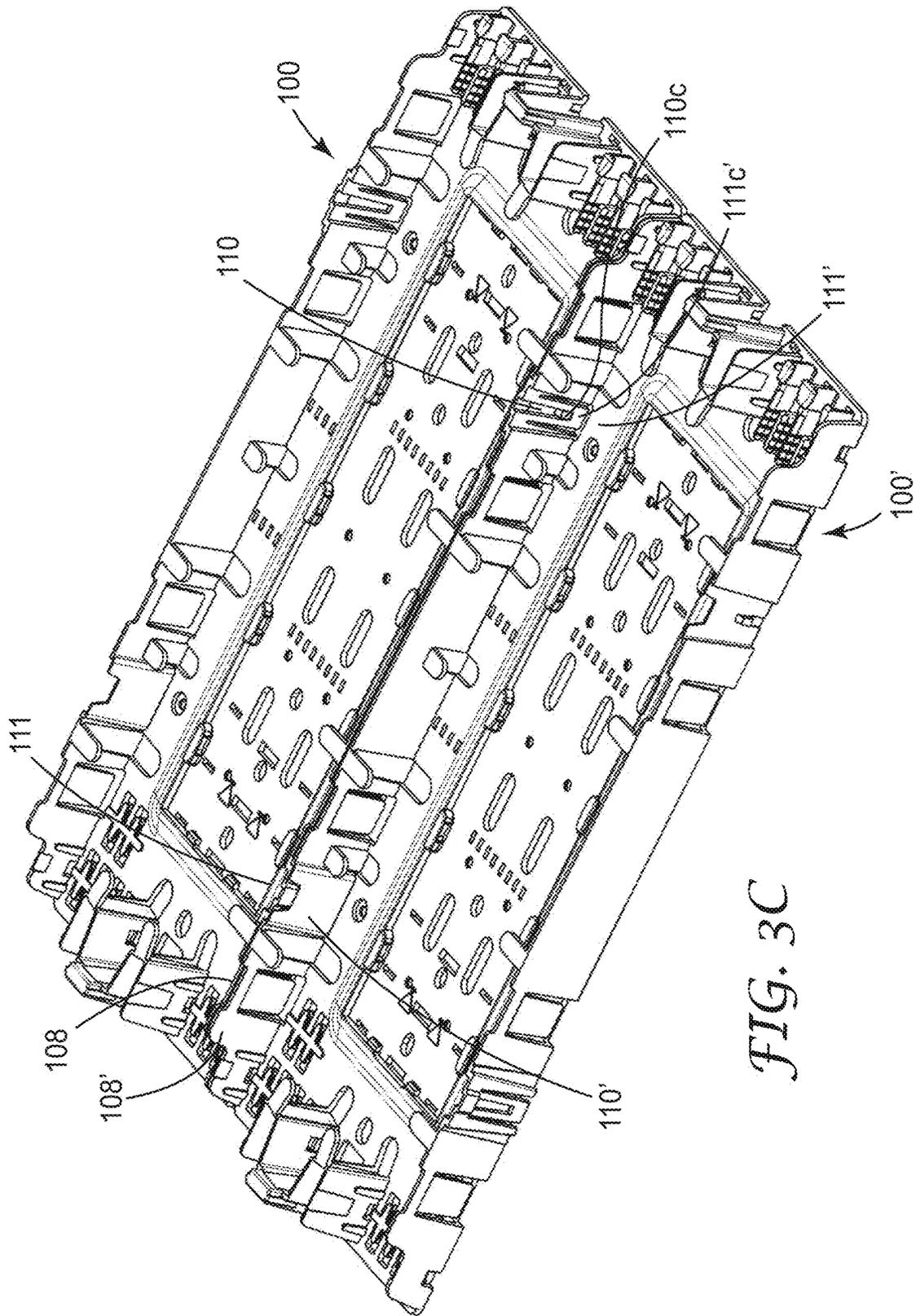


FIG. 3C

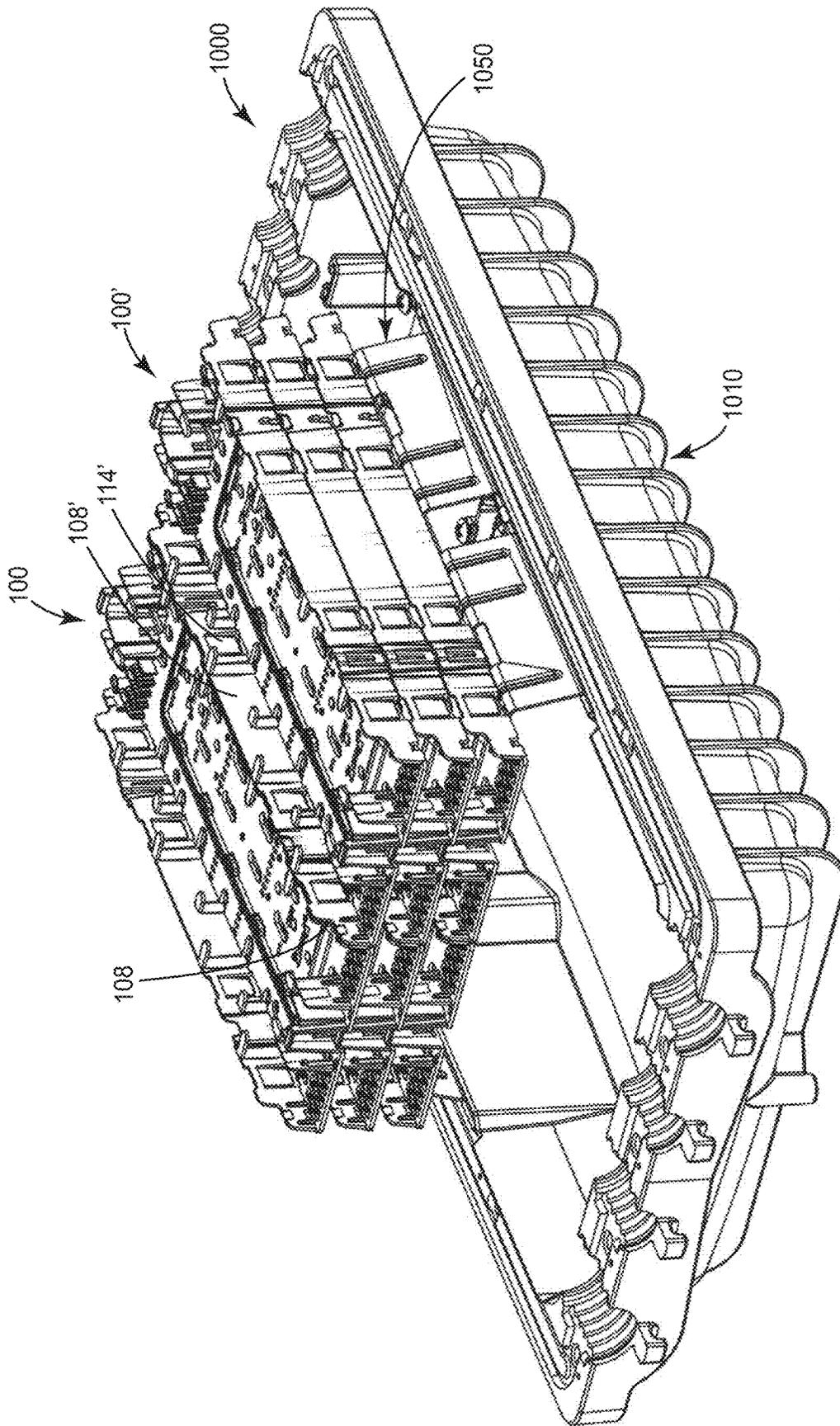
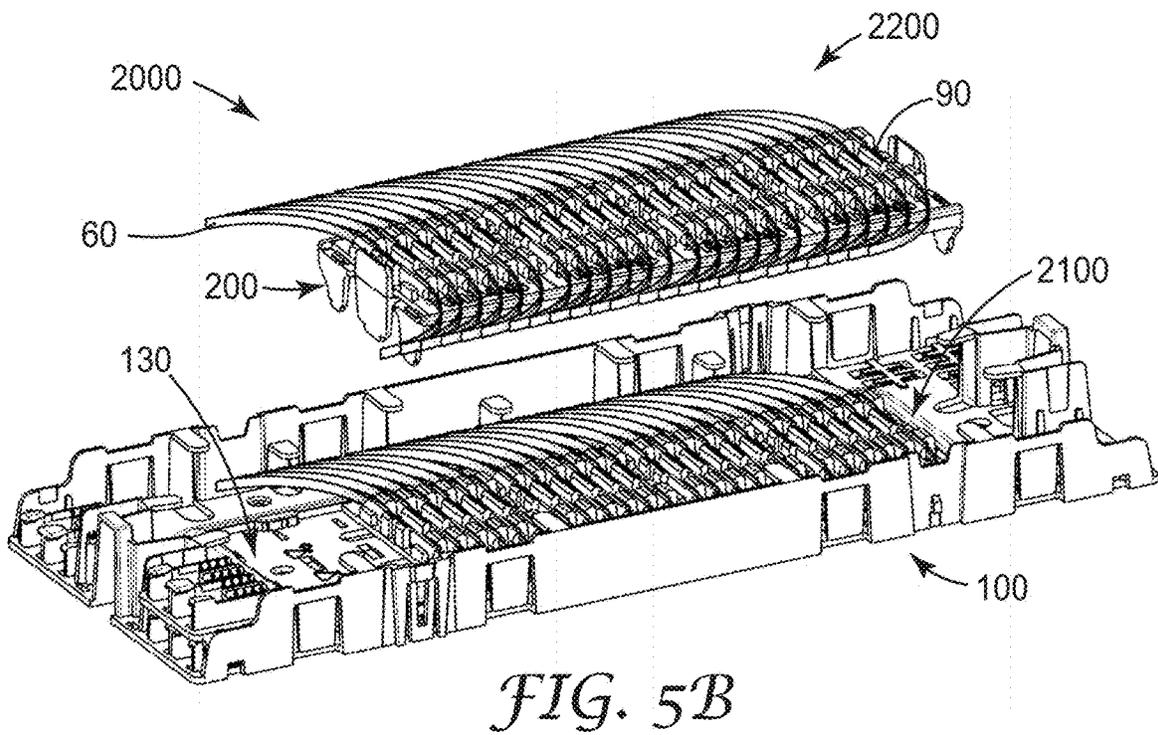
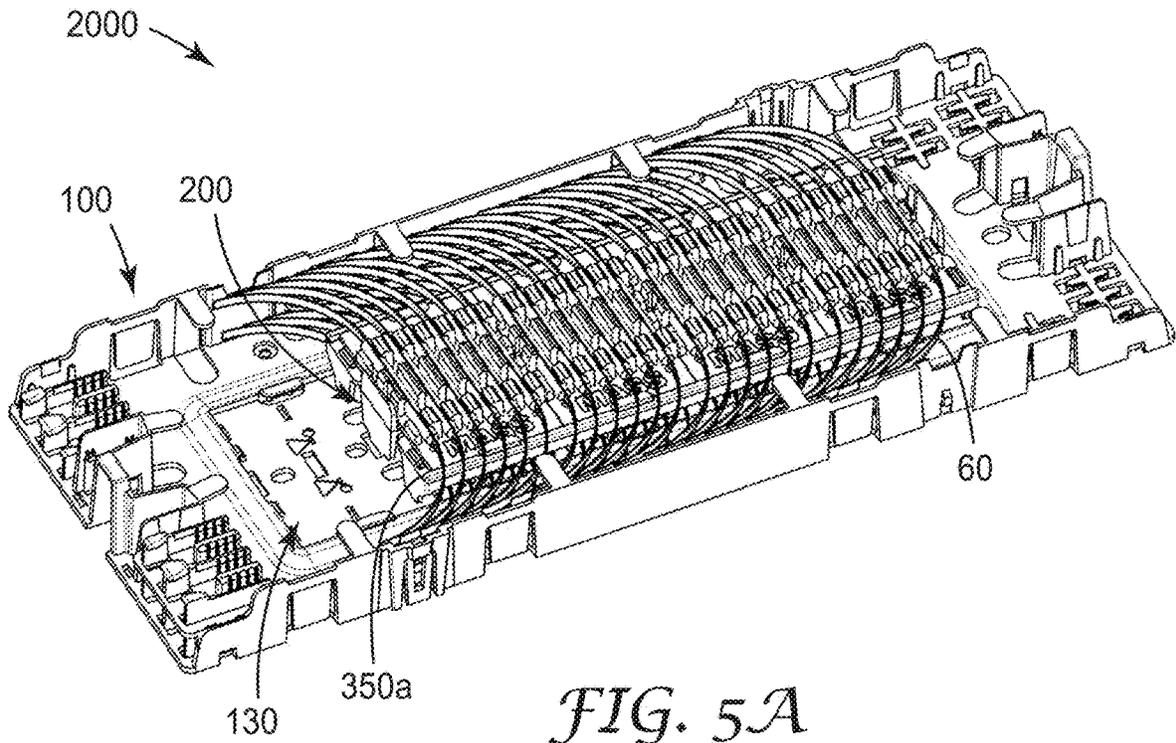


FIG. 4



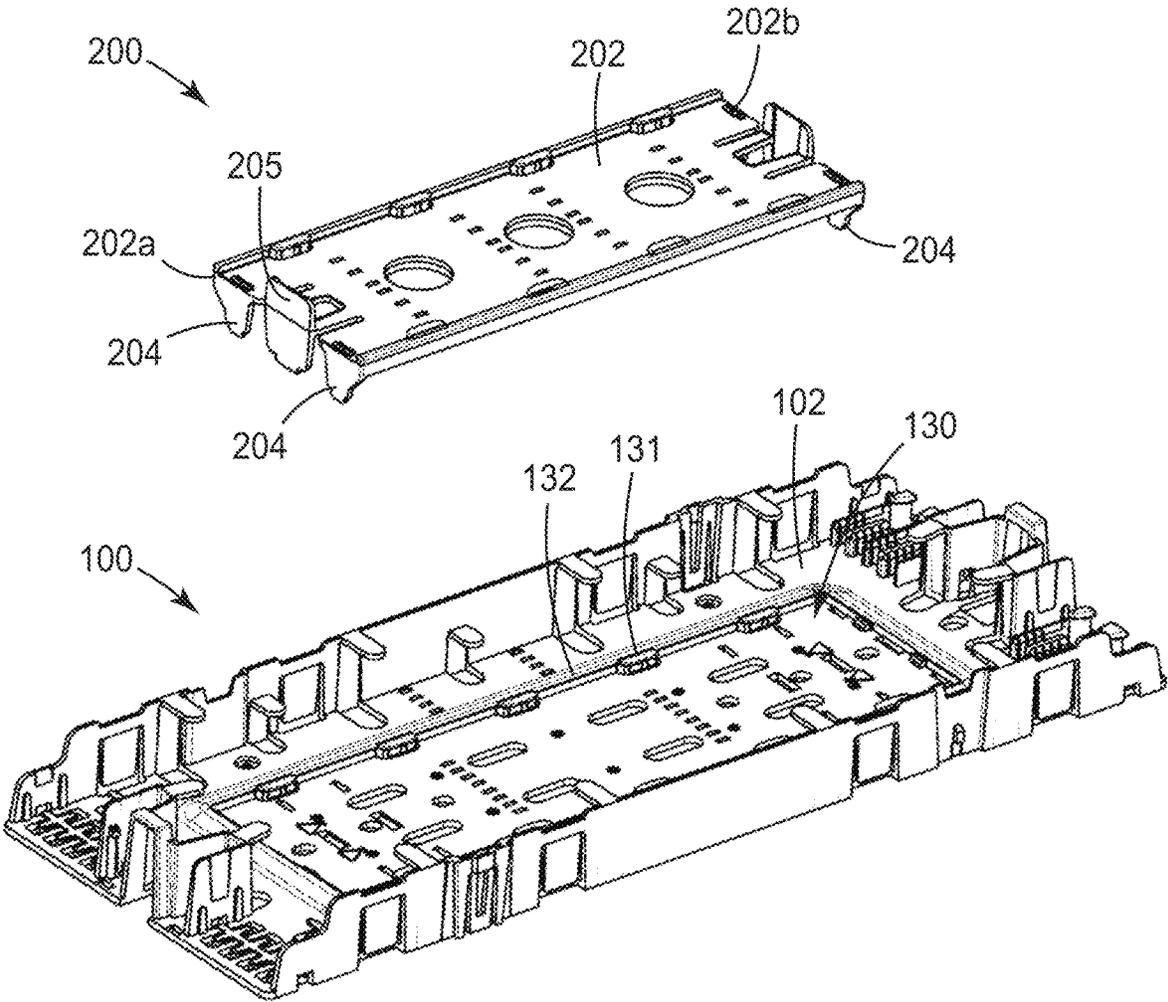


FIG. 6

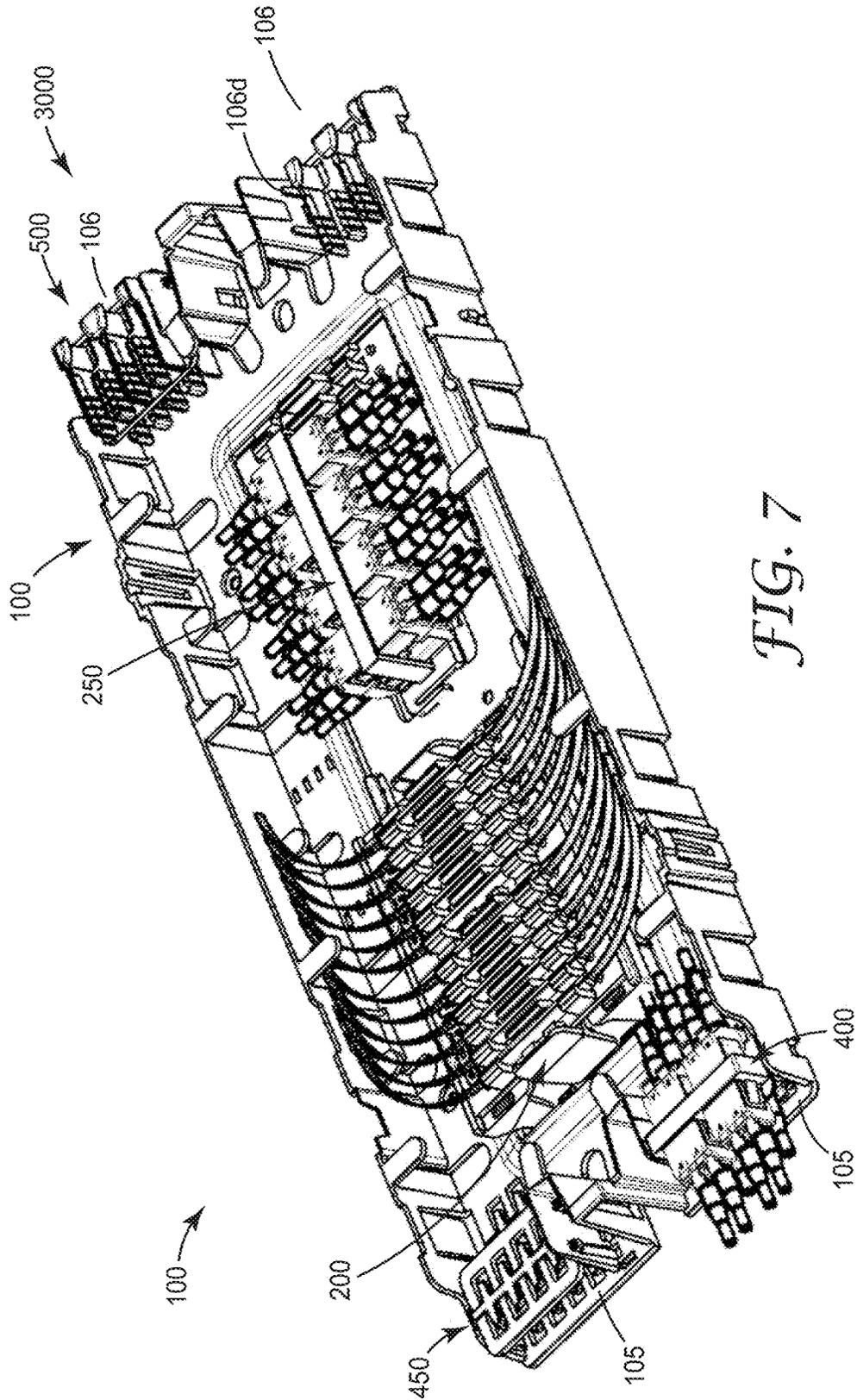


FIG. 7

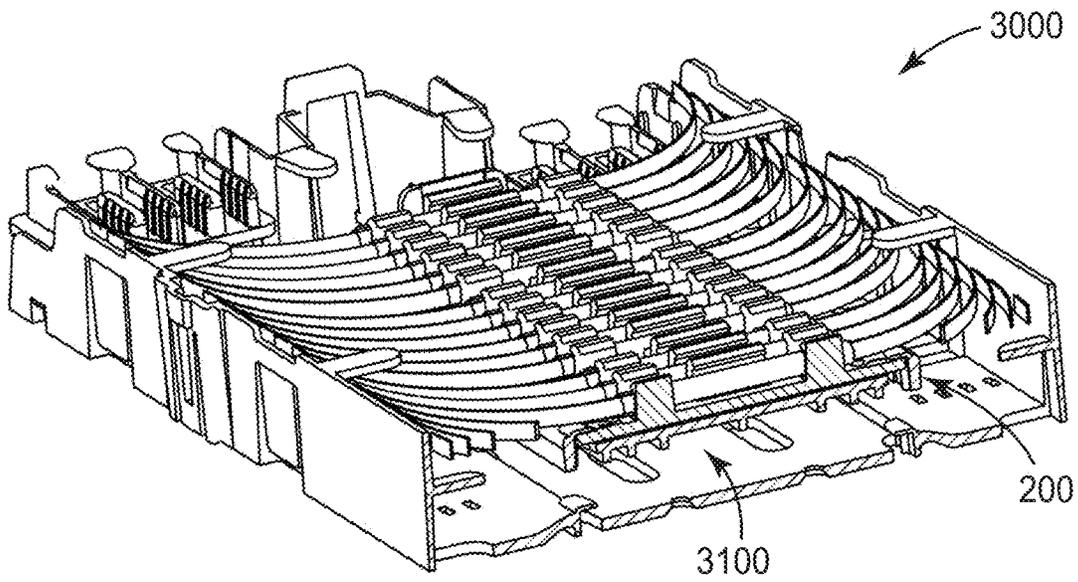


FIG. 8A

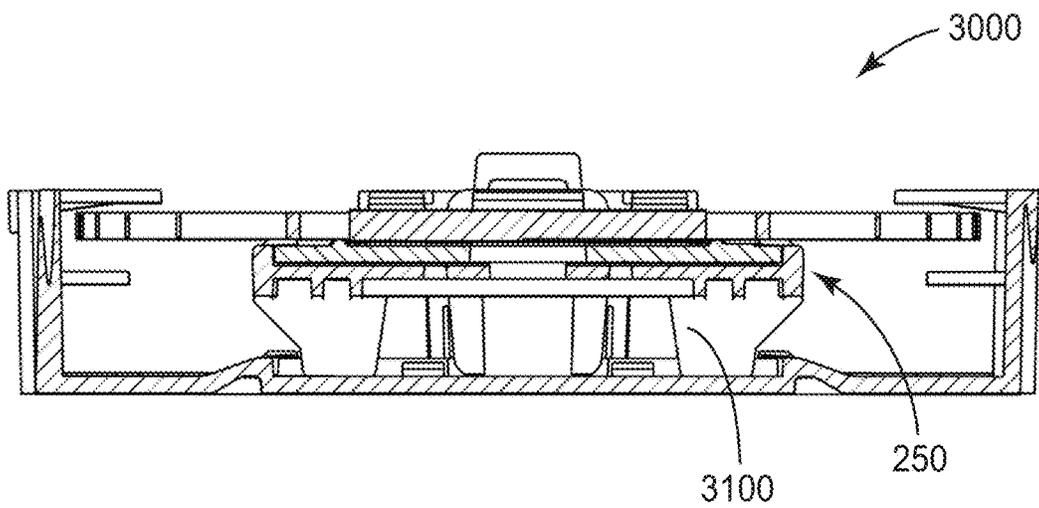


FIG. 8B

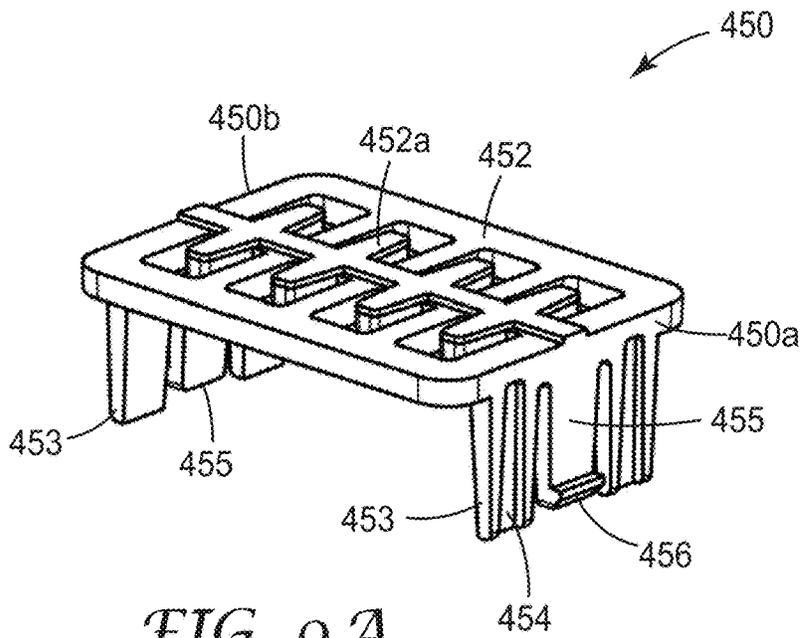


FIG. 9A

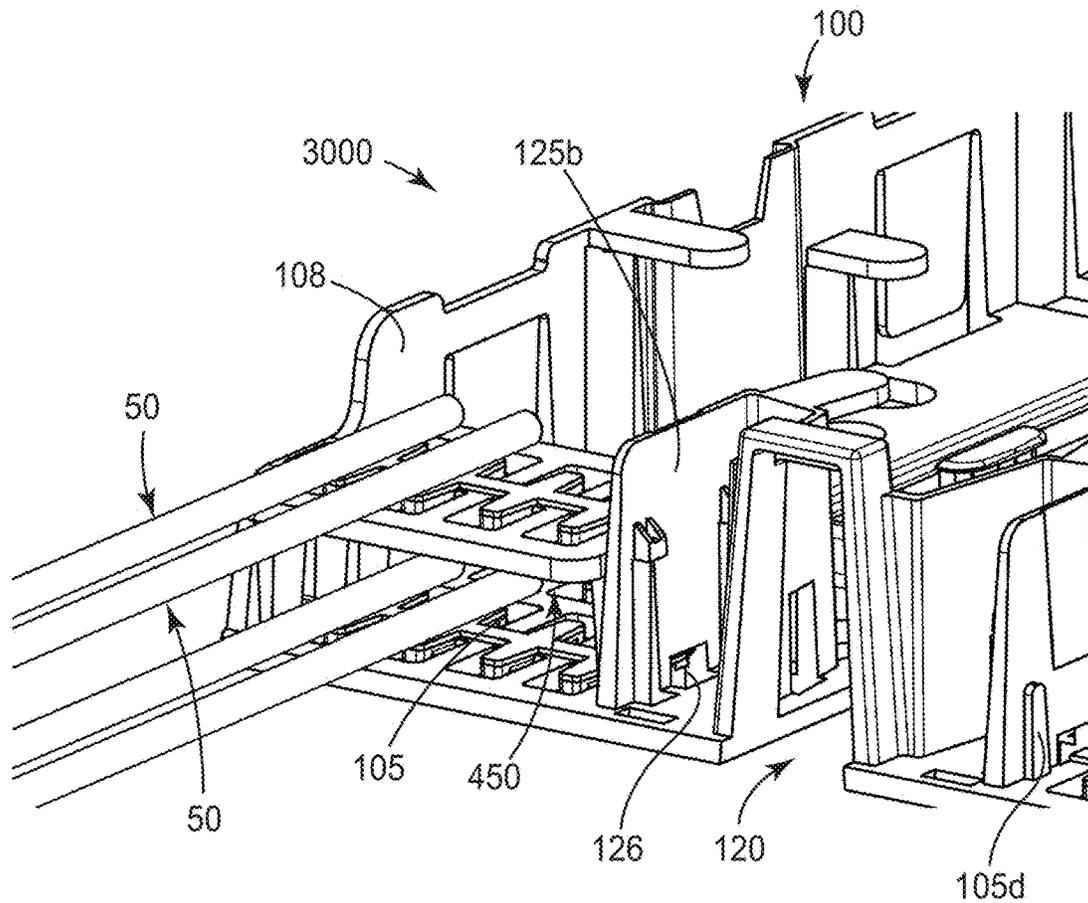


FIG. 9B

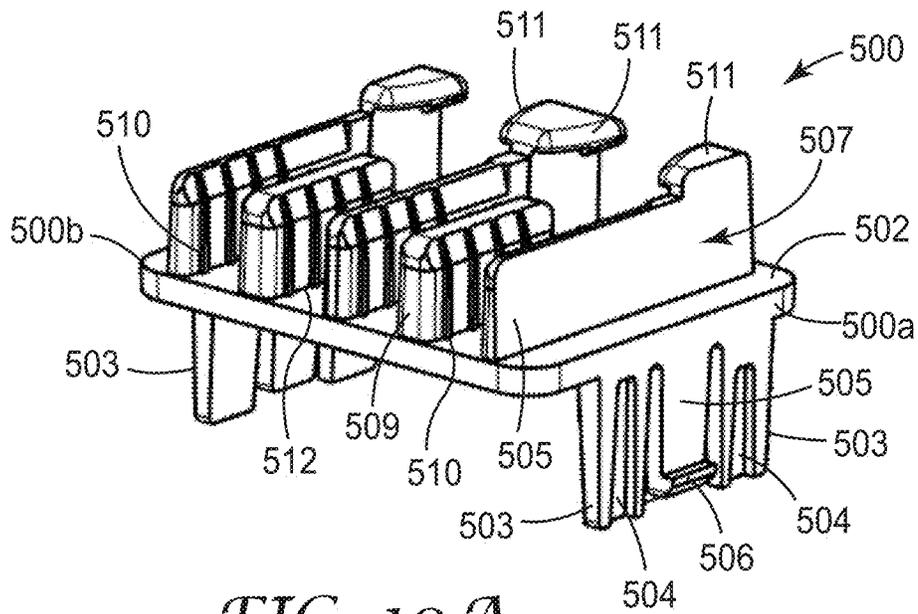


FIG. 10A

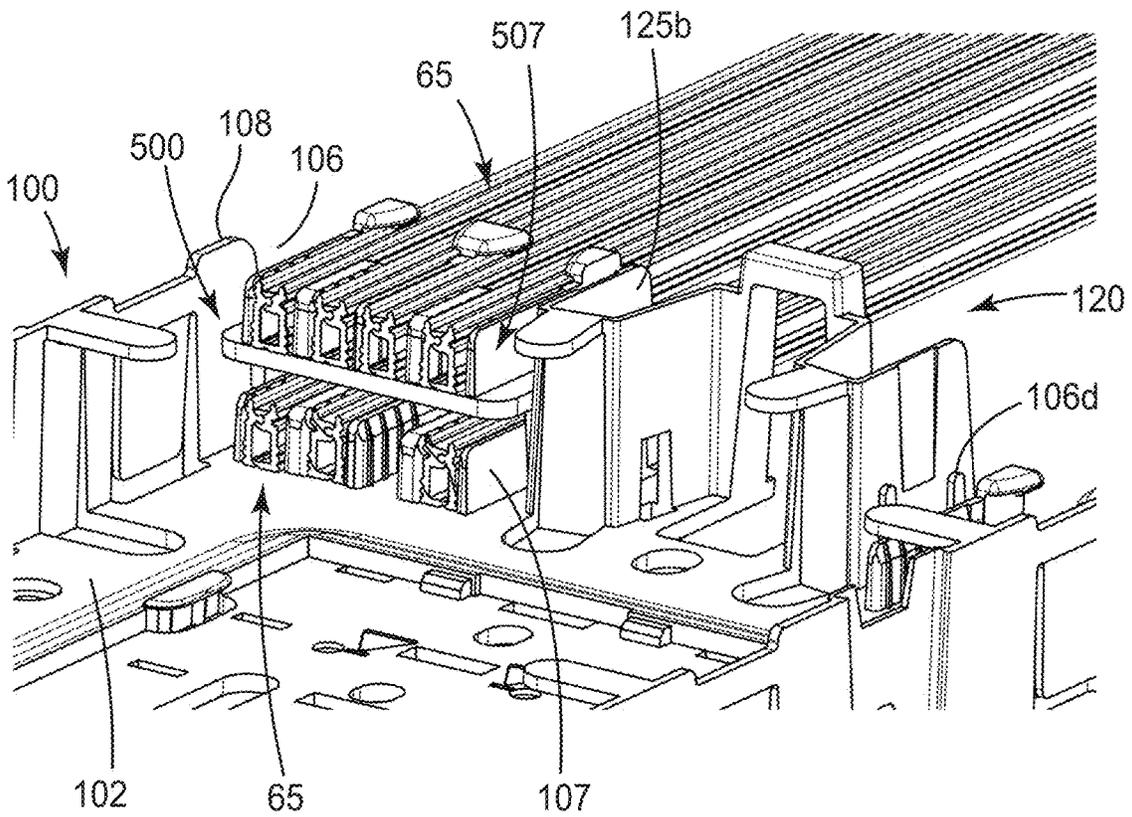


FIG. 10B

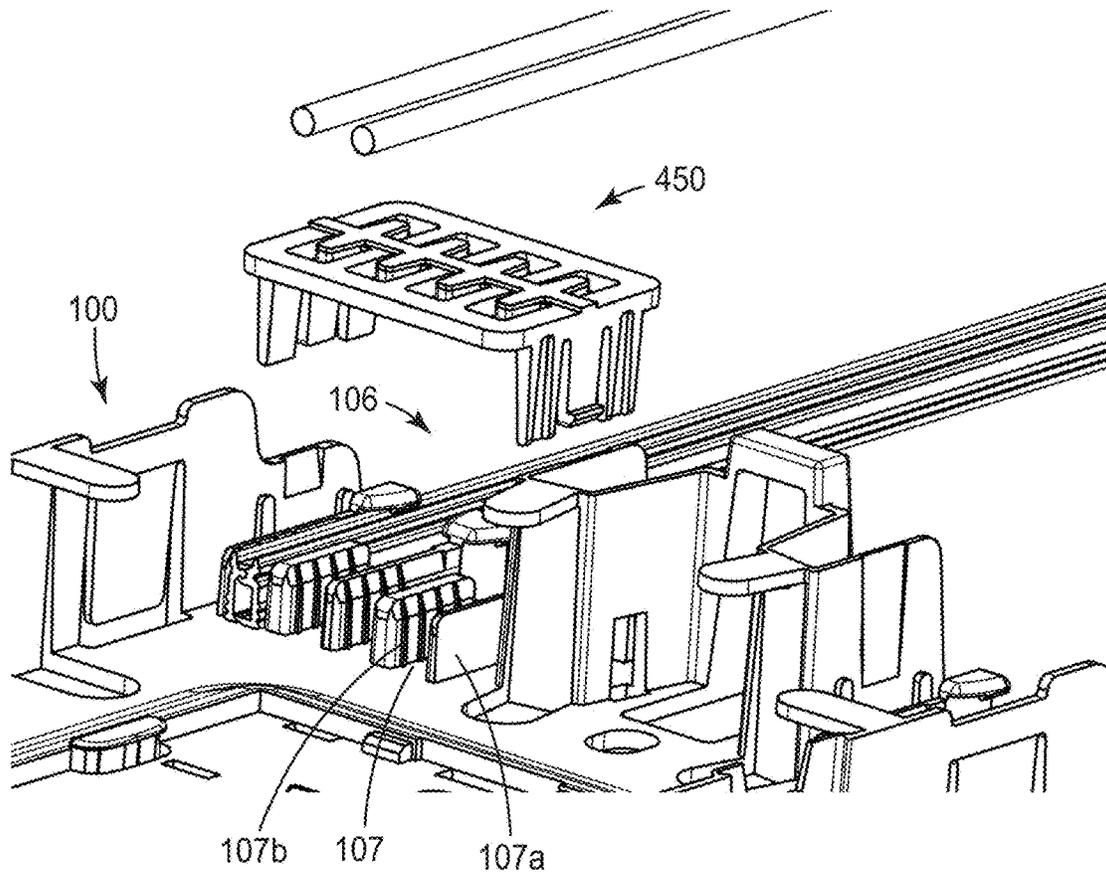


FIG. 11

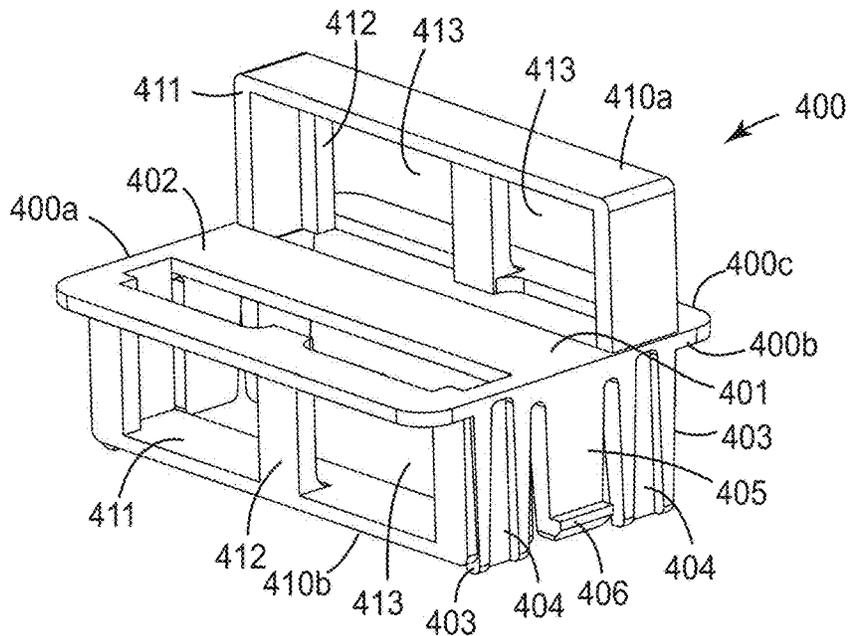


FIG. 12A



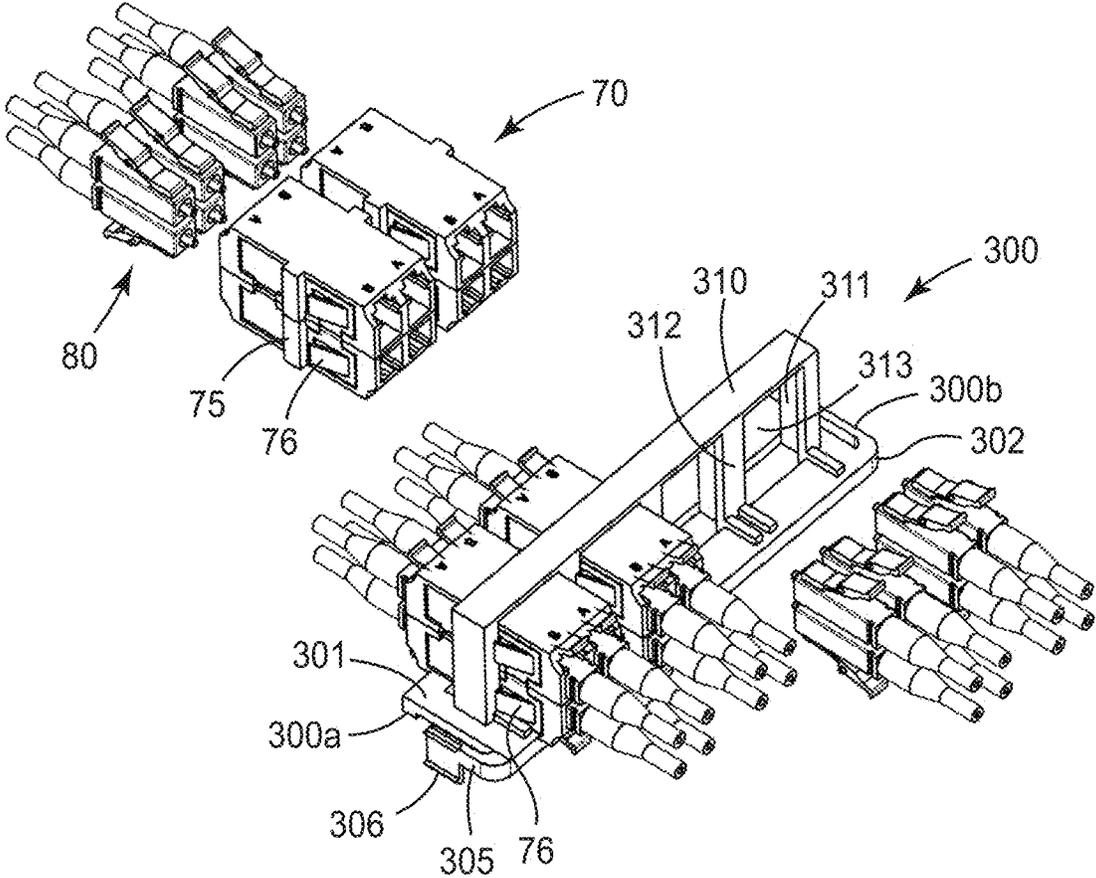


FIG. 13

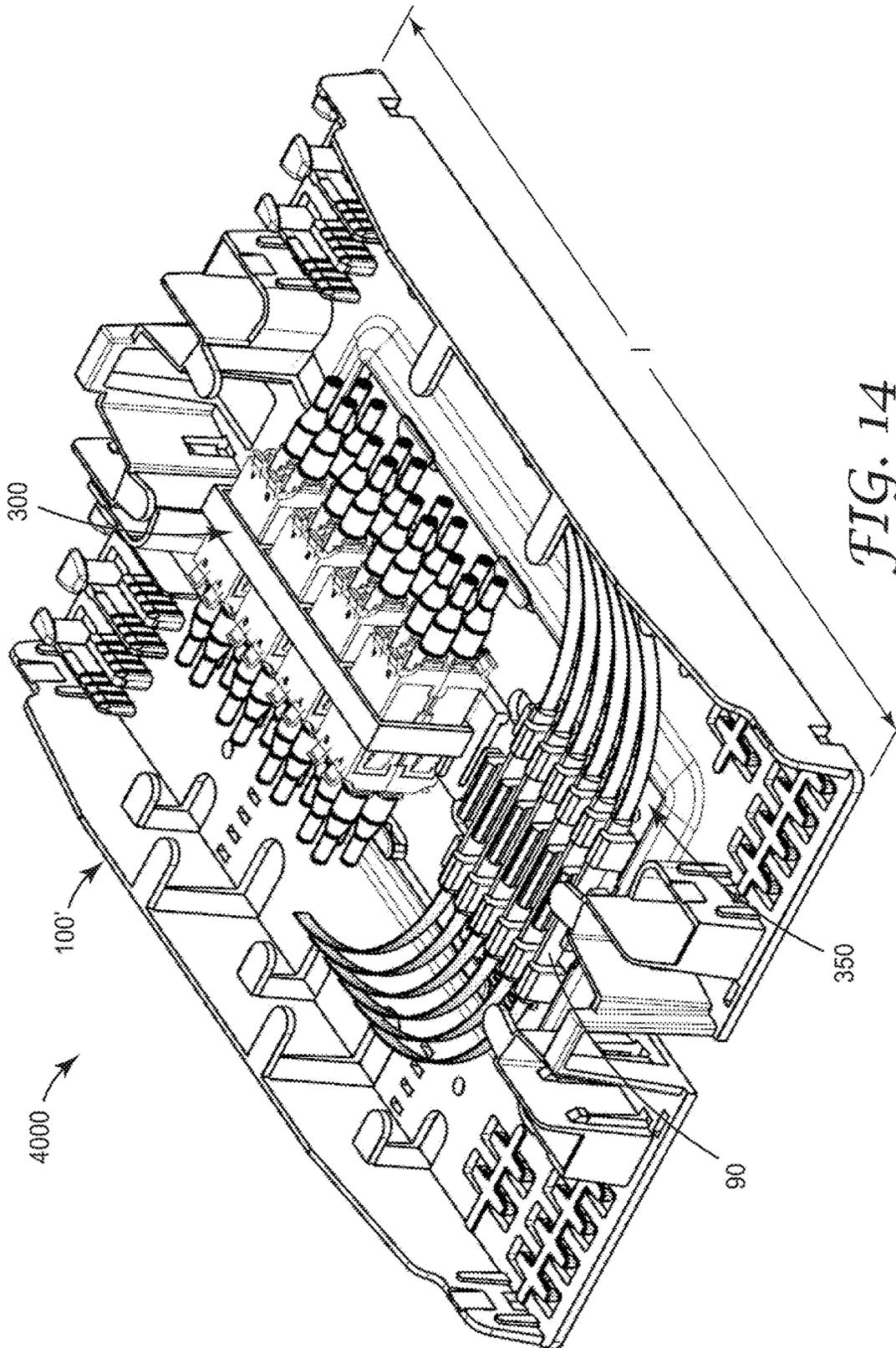


FIG. 14

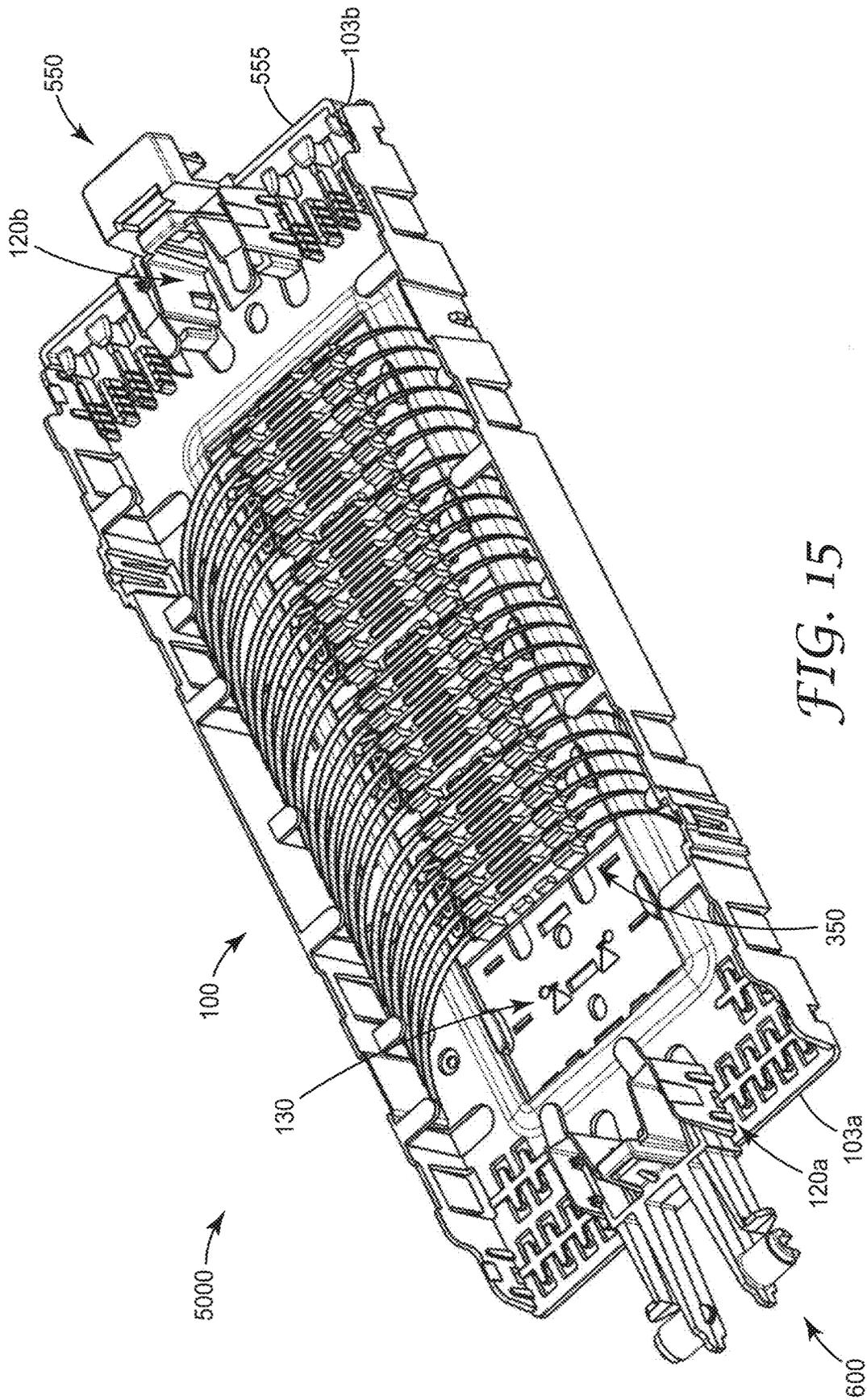


FIG. 15

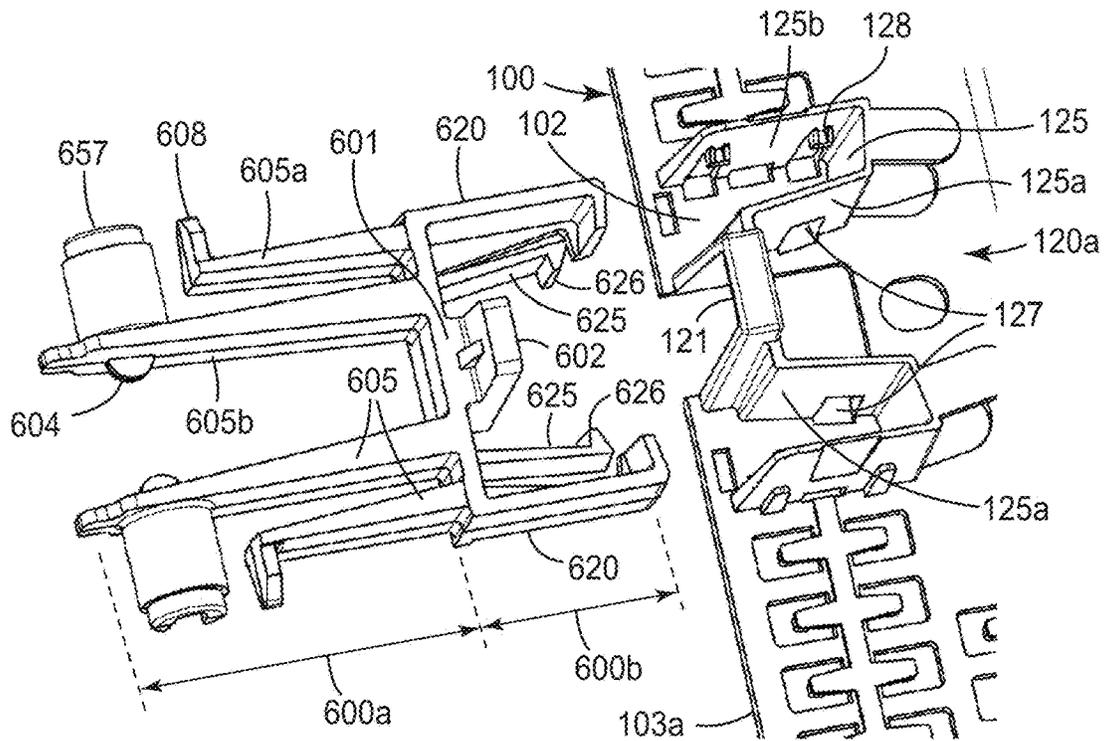


FIG. 16A

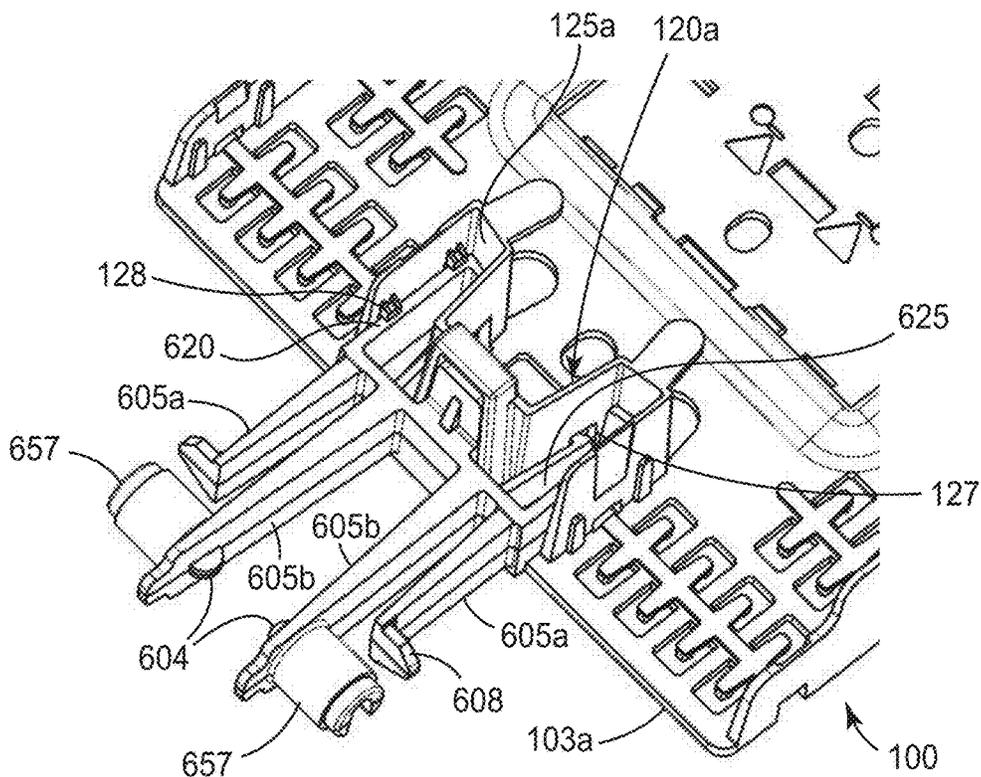


FIG. 16B

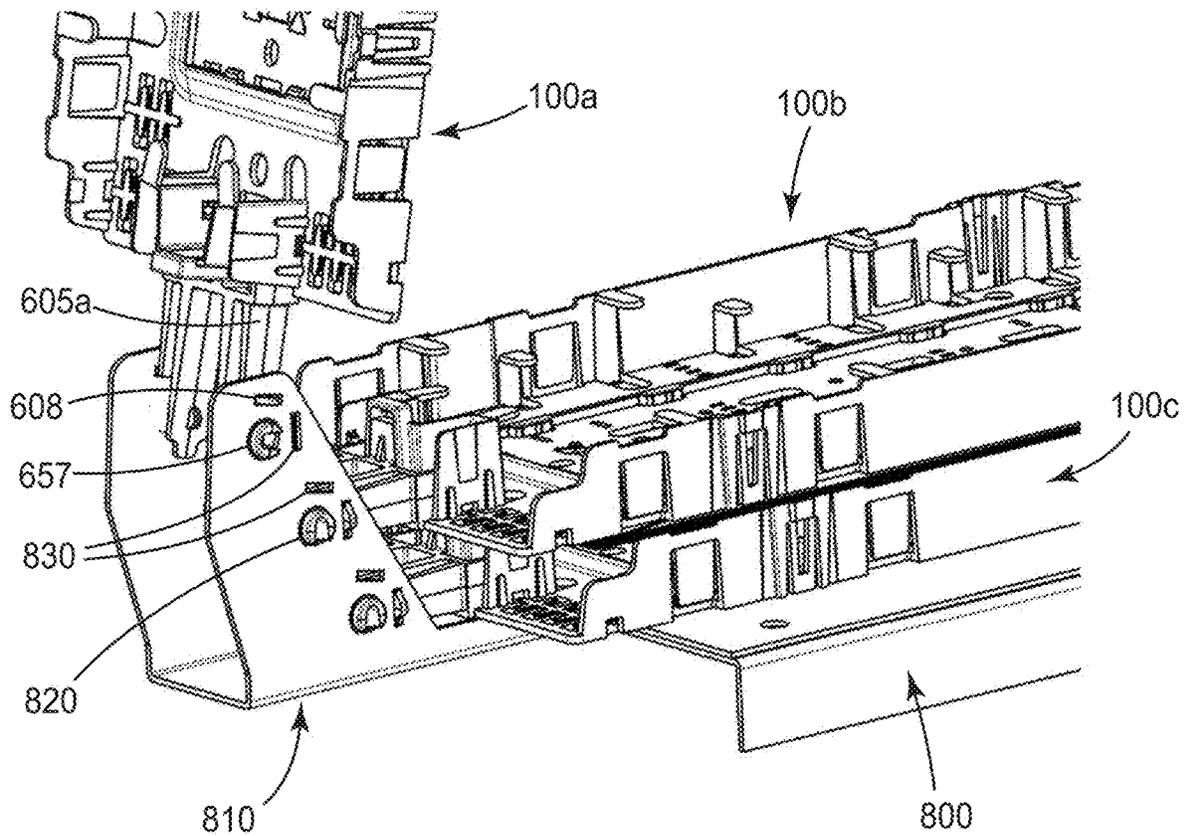


FIG. 16C



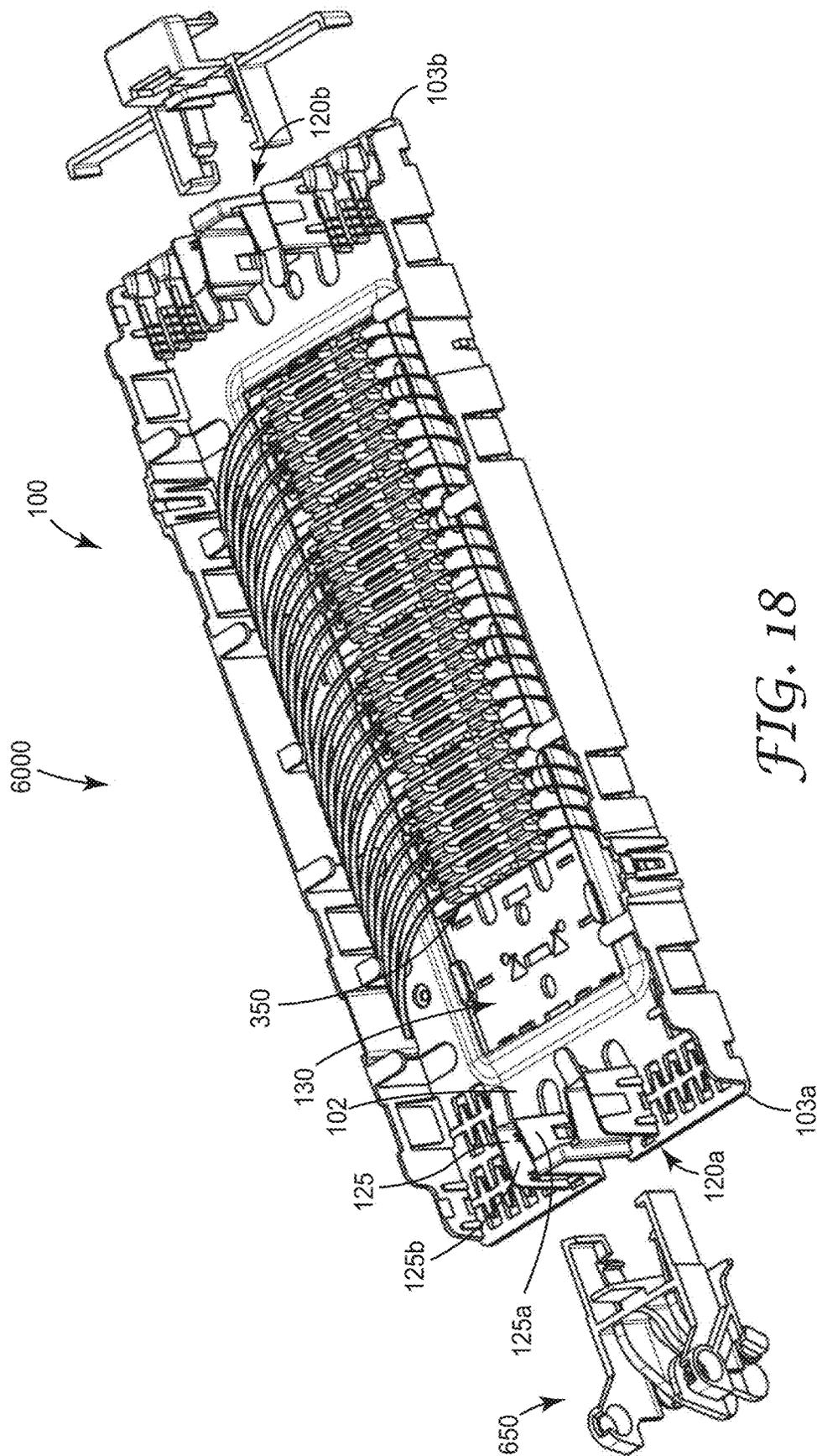


FIG. 18



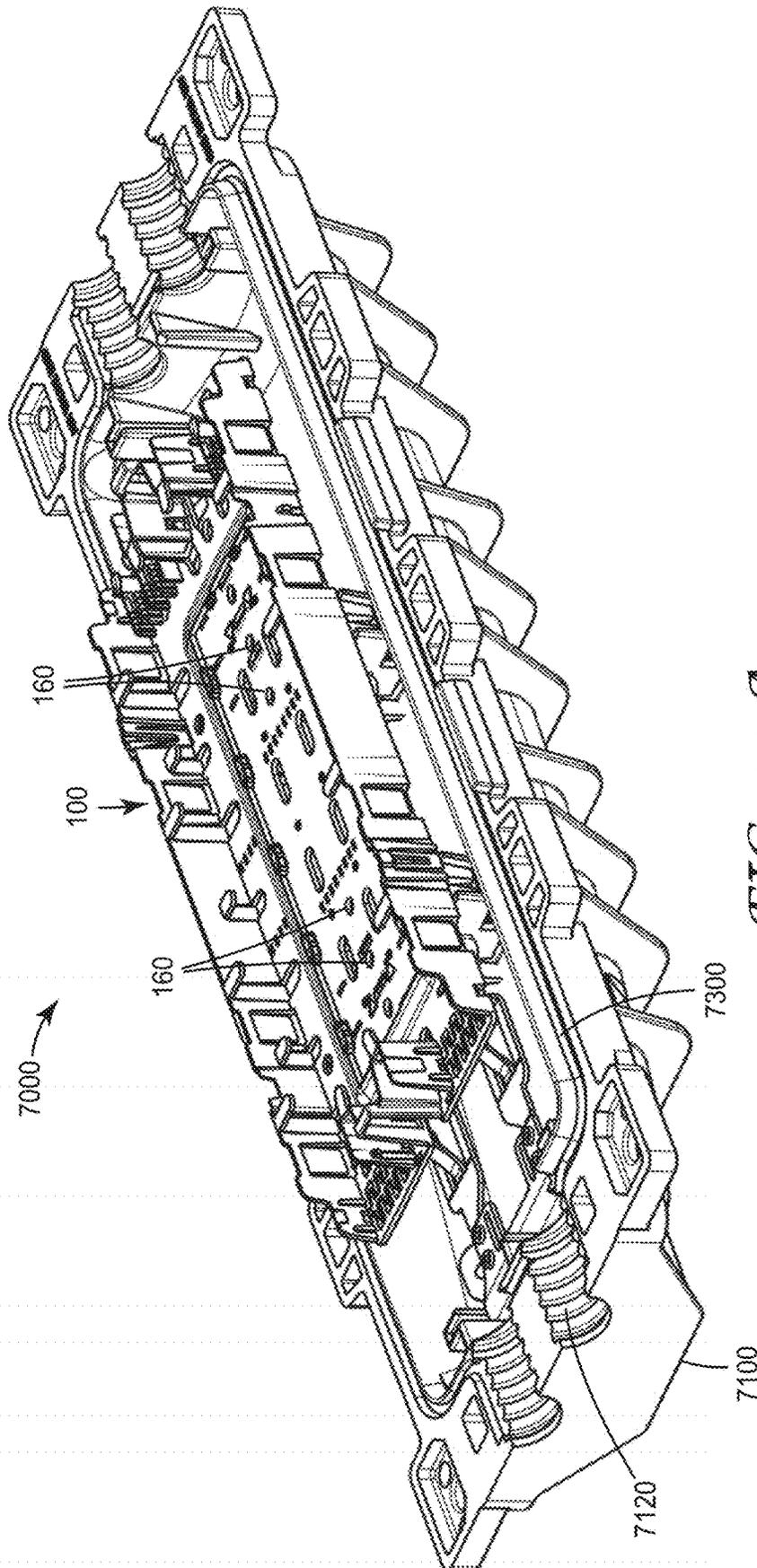


FIG. 20A

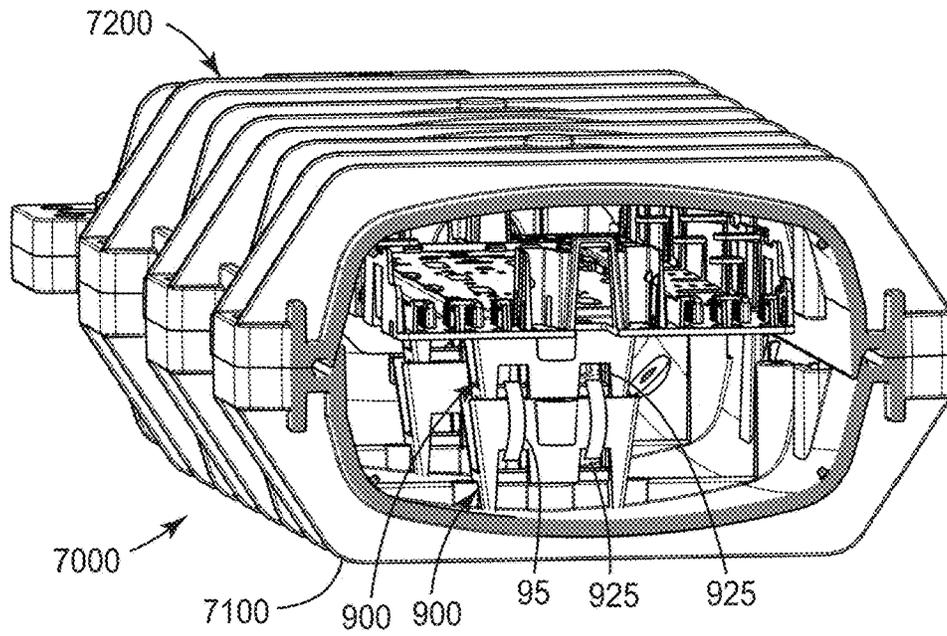


FIG. 20B

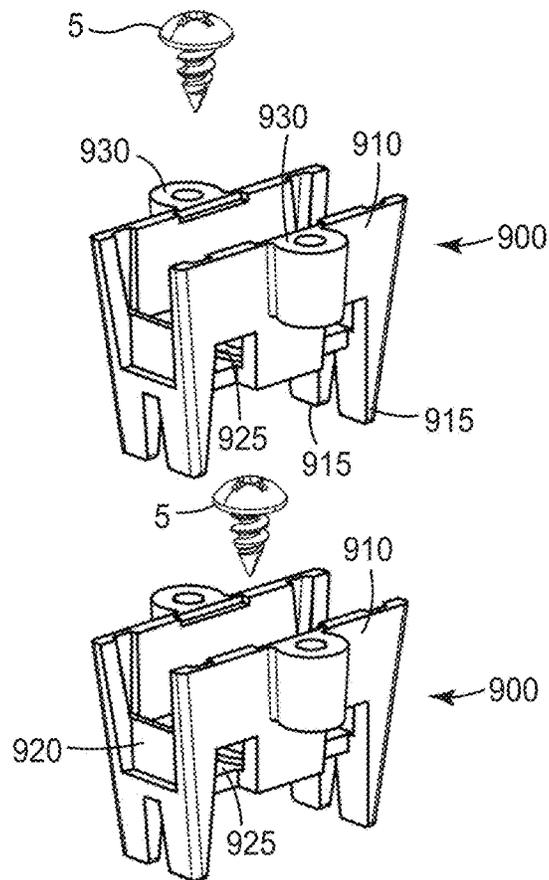


FIG. 20C

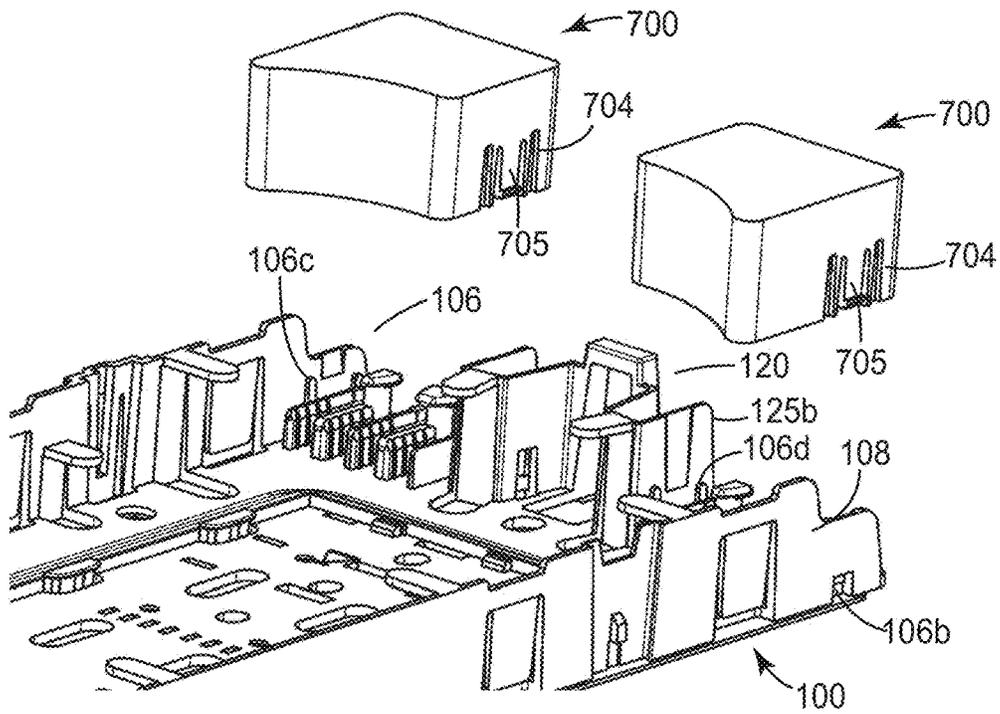


FIG. 21A

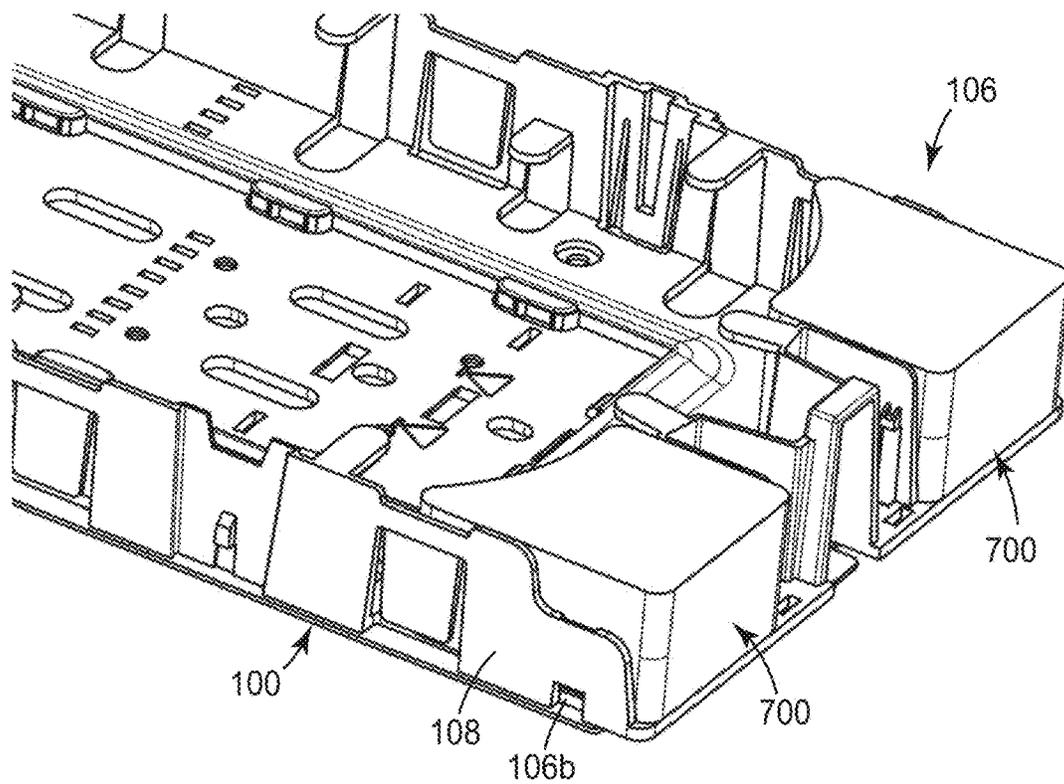


FIG. 21B

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## MODULAR OPTICAL FIBER SPLICE TRAY SYSTEM

### CROSS REFERENCE TO RELATED APPLICATIONS

This application is a continuation of International Application No. PCT/US2019/029580, filed Apr. 29, 2019, and claims the benefit of priority to U.S. Provisional Application No. 62/677,754, filed May 30, 2018. Each aforementioned application is relied upon and incorporated herein by reference in its entirety.

### FIELD

The present description relates to a modular, reconfigurable splice tray system for use in either inline or butt-style enclosures. In particular, a splice tray of the exemplary modular, reconfigurable splice tray system can be combined with a wide range of modular components to change not only the configuration of the splice tray, but the application space where the splice tray can be used.

### BACKGROUND

Telecommunication cables are used for distributing data across vast networks. Modern communication and data networks rely on fiber optic transmission lines or cables due to their high speed and low attenuation characteristics. As these fiber optic cables are routed across networks, it is necessary to periodically open the cable and splice or tap into the cable so that data may be distributed to “branches” of the network. The branches may be further distributed until the network reaches individual homes, businesses, offices, and so on. The distributed lines are often referred to as drop lines. At each fiber access point where the cable is opened, it is necessary to provide some type of enclosure to protect the cable (and potentially unjacketed fiber) and allow easy and repeated access to the cable. These enclosures need to provide features to store the fiber optic lines as well as allow for the interconnection between the incoming and outgoing fiber optic lines.

The purpose and configuration of the enclosure will vary depending on where the enclosure is located in a network. When an enclosure is used to interconnect distribution lines, the number of splices that can be made in the enclosure is a factor in determining which enclosure and which accessories within the enclosure are used. Frequently, telecommunication carriers want to use the smallest enclosure that can accommodate the needed number of splices due to factors like the cost of the enclosure, cost of installation, as well as aesthetics for above grade installations. At another point in the network, an enclosure can be used to distribute signals from a few optical fibers to many optical fibers through the use of optical splitters. While in another application, an enclosure may also contain a termination field for interconnecting optical fiber connectors.

As networks expand telecommunication carriers may want to add a cable to an existing fiber access point to increase capacity of a portion of the network or bring service to an area which did not have high speed, gigabit service previously. In order to do this the optical fiber interconnection capacity of enclosures at these fiber access points needs to increase.

Trays are a primary component used within communication enclosures to house optical fiber interconnection components such as optical fiber splices, optical splitters and the

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like. The shape and utility of a splice tray can differ depending on if the splice tray will be used in an inline or butt-style enclosure. Additionally, splice trays are typically sized for a particular size of enclosure. Both of these factors can lead to inventory issues in trying to manage the wide range of components needed to expand a fiber optic communication network.

Telecommunication service providers are asking for simpler more versatile enclosure systems.

### SUMMARY

The present description relates to a modular, reconfigurable splice tray system. In a first embodiment, the modular, reconfigurable splice tray system comprises a splice tray having a base extending longitudinally from a first end to a second end, a pair of side walls extending longitudinally between the first and second ends of the base, and a plurality of cable entrances formed at the first and second end of the base, wherein the base tray connection features that are configured to connect two splice trays together in a side-by-side configuration.

In a second embodiment, a modular, reconfigurable splice tray system comprises a splice tray having a base extending longitudinally from a first end to a second end, a pair of side walls extending longitudinally between the first and second ends of the base, a plurality of cable entrances formed at the first and second end of the base and a receiving portion configured to receive a modular component disposed between the cable entrances at the first end and at the second end.

The above summary of the present invention is not intended to describe each illustrated embodiment or every implementation of the present invention. The figures and the detailed description that follows more particularly exemplify these embodiments.

### BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be further described with reference to the accompanying drawings, wherein:

FIG. 1 is an exploded view of a modular, reconfigurable splice tray system of the present invention.

FIGS. 2A and 2B are two views of a splice tray of the modular, reconfigurable splice tray system of FIG. 1

FIGS. 3A-3C are detail views of a feature of the splice tray of FIGS. 2A and 2B FIG. 4 is a first exemplary configuration of the modular, reconfigurable splice tray system of the present invention.

FIGS. 5A and 5B are a second exemplary configuration of the modular, reconfigurable splice tray system of the present invention.

FIG. 6 is an isometric view of the modular components used in FIGS. 5A and 5B.

FIG. 7 is a third exemplary configuration of the modular, reconfigurable splice tray system of the present invention.

FIGS. 8A and 8B are detail views of the third exemplary configuration of the modular, reconfigurable splice tray system of FIG. 7.

FIGS. 9A and 9B are two views of a first cable entry component used in FIG. 7.

FIGS. 10A and 10B are two views of a second cable entry component used in FIG. 7.

FIG. 11 shows the use of the first cable entry component of FIG. 9A used in a hybrid cable arrangement.

FIGS. 12A and 12B shows a third cable entry component used in FIG. 7.

FIG. 13 is an isometric view of a modular fiber optic connector connection component used in FIG. 7.

FIG. 14 is a fourth exemplary configuration of the modular, reconfigurable splice tray system of the present invention.

FIG. 15 is a fifth exemplary configuration of the modular, reconfigurable splice tray system of the present invention.

FIGS. 16A-16C are three views of a first tray connection feature used in FIG. 15.

FIGS. 17A and 17B are two views of a second tray connection feature used in FIG. 15.

FIG. 18 is a sixth exemplary configuration of the modular, reconfigurable splice tray system of the present invention.

FIGS. 19A and 19B are two views of a third tray connection feature used in FIG. 18.

FIGS. 20A-20C illustrate one way that a splice tray of the modular, reconfigurable splice tray system can be mounted in an enclosure.

FIGS. 21A and 21B are two views of fiber guide components that close off an end of a conventional splice tray making the splice tray suitable for use in a butt-style enclosure.

While the invention is amenable to various modifications and alternative forms, specifics thereof have been shown by way of example in the drawings and will be described in detail. It should be understood, however, that the intention is not to limit the invention to the particular embodiments described. On the contrary, the intention is to cover all modifications, equivalents, and alternatives falling within the scope of the invention as defined by the appended claims.

#### DETAILED DESCRIPTION

Various exemplary embodiments of the disclosure will now be described with particular reference to the drawings. Exemplary embodiments of the present disclosure may take on various modifications and alterations without departing from the spirit and scope of the disclosure. Accordingly, it is to be understood that the embodiments of the present disclosure are not to be limited to the following described exemplary embodiments, but are to be controlled by the limitations set forth in the claims and any equivalents thereof.

In the following description, reference is made to the accompanying drawings that forms a part hereof and in which are shown by way of illustration. It is to be understood that other embodiments are contemplated and may be made without departing from the scope or spirit of the present disclosure. The following detailed description, therefore, is not to be taken in a limiting sense.

Spatially related terms, including but not limited to, "lower," "upper," "beneath," "below," "above," and "on top," if used herein, are utilized for ease of description to describe spatial relationships of an element(s) to another. Such spatially related terms encompass different orientations of the device in use or operation in addition to the particular orientations depicted in the figures and described herein. For example, if an object depicted in the figures is turned over or flipped over, portions previously described as below or beneath other elements would then be above those other elements.

As used herein, when an element, component or layer for example is described as forming a "coincident interface" with, or being "on" "coupled with" or "in contact with" another element, component or layer, it can be directly on, directly coupled with, in direct contact with, or intervening elements, components or layers may be on, connected,

coupled or in contact with the particular element, component or layer, for example. When an element, component or layer for example is referred to as being "directly on," "directly coupled with," or "directly in contact with" another element, there are no intervening elements, components or layers for example.

The modular, reconfigurable splice tray system described herein is a highly configurable splice tray system that can be used to interconnect optical fibers. The optical fibers can be in the form of individual 250  $\mu\text{m}$  coated optical fibers, 900  $\mu\text{m}$  buffer coated optical fibers, small diameter jacketed cables, optical fibers contained in buffer tubes, or optical ribbon fibers. For example, the modular, reconfigurable splice tray system can be used with ribbon fiber cables, such as the RocketRibbon™ Extreme Density Cable available from Corning, Inc. (Corning, N.Y.).

The modular, reconfigurable splice tray system can be used for splicing ribbon and discrete fiber containing stackable cable entry devices. The style of the cable entry region of a splice tray can be changed by utilizing snap-in cable entry components. In some embodiments the snap-in cable entry components allow multi-level fiber entry attach points. While in other embodiments, the snap-in cable entry components can be used to mount fiber optic connector adaptors enabling optical fiber connector connections in the cable entry region of the splice tray.

The splice tray of the exemplary system has interconnection features which permit attaching two or more of the splice trays in a side by side arrangement creating a larger tray having multiple compartments. The wall between adjacent compartments include removable partitions for fibers to pass between compartments. Tray expansion features are self-mating and require no additional parts.

The modular, reconfigurable splice tray system includes additional snap-in modular components to increase the trays splice density using a removable splice insert riser. In another aspect, the removable splice insert riser can be removed from the splice tray during the splicing and reinstalled in the tray afterwards. In some applications, the space under the insert riser can be used to manage and store the ribbon fiber.

Other snap in modular components enable the conversion of a flat stacked splice tray to pivoting splice tray. Common structural design of the modular components allows parts to be mixed and matched for use across a line of splice trays.

FIG. 1 shows a selection of the modular components that can be assembled onto an exemplary splice tray 100 in the modular, reconfigurable splice tray system. The exemplary components can be mixed and matched and attached to splice tray 100 in a large number of different configurations. The modular components can include a tray cover 150; optical component risers 200, 250; optical connector adapter holder 300; optical component holders 350; snap-in cable entry components 400, 450, 500; a latch component 550; snap-on hinge components 600, 650; and fiber guide components 700 (FIG. 21A-21B).

FIG. 2A shows an exemplary splice tray 100 for use in the modular, reconfigurable splice tray system. Splice tray 100 has a rectangular shape and can be characterized by its dimensions: Length, L; Width, W; and Depth, D. The depth of the tray can be between 12 mm and 25 mm so that the splice tray has sufficient vertical clearance to allow crossing over of optical fiber ribbons or buffer tubes. In an exemplary aspect, the length of the tray can be between 200 mm and 350 mm and the width of the tray can be about 75 mm to about 150 mm. In an alternative aspect the exemplary splice tray may have other dimensions depending on the enclosure in which they are to be placed.

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Splice tray **100** has tray body **101** comprising a base **102** extending longitudinally from a first end **103a** to a second end **103b**, wherein the base includes first cable entrances **105** at the first end of the splice tray and second cable entrances **106** at the second end of the splice tray. Side walls **108** extend along the longitudinal edges of the base between cable entrance **105**, **106** on either side of the tray. The splice tray includes an interconnection area **130** along its longitudinal central axis and a fiber routing area **115** around the interior circumference of the splice tray. In an exemplary aspect, the interconnection area on the splice tray can have a shallow channel formed in the base that is configured to accept a plurality of optical component holders **350** (FIG. 1).

A first receiving portion **120a** is disposed at the first end **103a** of the splice tray **100** between the first cable entrances **105** and a second receiving portion **120b** is disposed at the second end **103b** of the splice tray between the second cable entrances **106**. In the embodiment shown in FIG. 2A, the first and second receiving portions **120a**, **120b** are structurally similar and will be referred to as receiving portion **120**. The receiving portions facilitate the attachment of several of the modular components to the splice tray. In particular, receiving portions facilitate the attachment of tray cover **150**, a latch component **550**, and snap-on hinge components **600**, **650**, shown in FIG. 1. Additionally, the receiving portions also provide a feature to anchor one side of the snap-in cable entry components **400**, **450**, **500** when they are disposed in one or more of the cable entrances.

FIG. 2B is a detail view of a first end **103a** of splice tray **100**. Receiving portions **120** include a frame portion **121** centered between a pair of connection bays **125**. Frame **121** can have an open trapezoidal shape and be positioned over an opening **104** in the base **102** of the splice tray. The frame portions **121** include two inclined columns **121a** and a top beam **121b**. In one aspect, the frame portions as the ends of the splice tray can be nested or partially inserted into the frame portion of another splice tray to align two or more splice trays when they are disposed in a vertical stack as shown in FIGS. 2B and 4. Connection bays **125** include side partitions **125a**, **125b** and an end partition **125c** (FIG. 2A). The side partitions may be angled such that the entrance to the connection bays is wider than the end partition to facilitate connection of the modular components. Connection openings **126**, **127** can be formed in the side partitions; the connection openings being configured to accept connection latches of the modular components, which will be described in more detail regarding the individual connection components below.

In some applications, frame portion **121** can accept a tab portion **152** of cover **150** between columns **121a** and beneath top beam **121b** to secure the cover over the open face of the splice tray.

In one aspect, splice tray **100** can include four cable entrances **105**, **106** adjacent to the corners of the splice tray. Cable entrances **105** include a plurality of tie down points **105a** to strain relieve cables, cable sub units or buffer tubes containing individual optical fibers or fiber ribbons entering and exiting the exemplary splice tray. The entering and exiting cables or buffer tubes can be secured to the tie downs by conventional cable ties. Cable entrances **106** include a plurality of gripping structures **107** to strain relieve cables, self-closing extruded fiber tube or zip tube, or buffer tubes containing individual optical fibers or fiber ribbons entering and exiting the exemplary splice tray. Each gripping structure comprises a pair of parallel wall sections **107a** and a plurality of teeth or barbs **107b** (shown in FIGS. 2A and 11) on the facing surfaces of the wall sections that will grip onto

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the surface of the cable, zip tube or buffer tube passing through the gripping devices. The pair of parallel wall sections comprise a long wall section and a short wall section. The long wall sections have a hold-down feature **107c** formed at the top of an end of each long wall section that extend at least part way over a cable channel through the gripping device. The center long wall section has two hold-down features formed at the top of an end thereof extending at least part way over the cable channels on either side of the center long wall section. The hold-down features are configured to retain the cables, zip tubes or buffer tubes in the gripping structure.

While tray **100** is shown as having two different two different cable entrance structures at the first and second ends of the splice tray, one of ordinary skill in the art will recognize that all of the cable entrances in the tray can comprise all of cable entrance **105** or all of cable entrance **106**, and thus is considered to be within the scope of the invention as it is described herein.

Side walls **108** and the end partitions **125c** of the receiving portions **120** of splice tray **100** define the outer circumference of fiber routing area **115**. The fiber routing area can be used to store excess lengths of optical fiber between the outer walls of the splice tray (i.e. side wall **108** and end partitions) as well as provide space for routing optical fibers to and from interconnection area **130**. A plurality of tabs **109a** can extend from the top edges of the side walls of the splice tray and the guide walls to help retain the optical fibers within the boundaries of the splice tray. Auxiliary tabs **109b** can extend from side walls **108** into the fiber routing area to help manage a first fiber slack layer below the auxiliary tabs and support a second slack fiber layer above the auxiliary tabs.

Referring to FIG. 2A and FIGS. 3A-3B, each side wall **108** can include tray connection features **110** and **111** to connect two splice trays together in a side by side configuration. Tray connection features **110** comprise a depression **110a** formed in the exterior surface of sidewall **108** and a latching protrusion **110c** extending from the bottom depression and configured to mate with latch **111c** of connection feature **111'** in a second splice tray **100'** shown in FIGS. 3B and 3C. In an exemplary aspect, depression **110a** can have a dove tail shape with an overhanging lip **110b** (FIG. 3B) forming the female dovetail connection feature. FIG. 3A is a detail view of connection feature **111**, which is in the form of the male dove tail feature that mates into the female dovetail connection feature **110**. Connection feature **111** comprise a pair of vertical guide rails **111a** and latch **111c**. The guide rails are inclined to engage with the dovetail depression and have an undercut portion **111b** that is configured to retain the overhanging lip **110b** of connection feature **110**.

FIGS. 3B and 3C shows two splice trays **100**, **100'** connected together with via connection features **110**, **111'** on the side walls **108**, **108'** of the first and second splice trays, respectively, in FIG. 3B the engagement between the overhanging lip **110b** of the first connection feature **110** with undercut portion **111b'** of the second connection feature **111'**.

FIG. 4 shows a stack of duplexed splice trays **100**, **100'** disposed on a splice tray platform **1050** attached to the base **1010** of an enclosure **1000**. The side walls **108**, **108'** of the duplexed splice trays include removable portions **114**, **114'** (FIGS. 3A-3C and 4) that when removed provide pass throughs to facilitate routing of optical fibers and or ribbons between the duplexed splice trays.

FIGS. 5A-5B and 6 show one configuration of the modular, reconfigurable splice tray system in the form of a high

density ribbon fiber splice tray. Ribbon fiber splice devices **90** are arranged in optical component holders, in particular mass fusion splice holders **350A** in two layers. The first layer is disposed in interconnection area **130** and the second layer is disposed on a detachable optical component riser **200**.

FIGS. **5A-5B** and **6** show one configuration of the modular, reconfigurable splice tray system in the form of a high density ribbon fiber splice tray **2000**. Ribbon fiber splice devices are arranged in optical component holders, in particular mass fusion splice holders **350A** in two interconnection layers **2100** and **2200**. The first interconnection layer **2100** is disposed in interconnection area **130** and the second interconnection layer **2200** is disposed on a detachable optical component riser **200**.

Interconnection area **130** can accommodate a variety of optical components. Optical components may include optical fiber splices (e.g. mechanical splices, fusion splices, mass fusion splices or mass mechanical splices), optical splitters and optical connector adapters. The splices can be disposed in conventional optical component holders **350**; the optical splitter can be disposed in an optical splitter holder and the optical fiber adapter can be held in a modular connector adapter holder **300** (Shown for example in FIGS. **1**, **13** and **14**). In an exemplary aspect, the interconnection area can include a first interconnection layer disposed on a base of the splice tray, and a second interconnection layer positioned over at least a portion of the first interconnection layer.

Up to five optical component holders can be disposed in Interconnection area **130** of splice tray **100**. In the embodiments shown in FIGS. **5A-5B**, the interconnection area holds four optical component holders **350A**. Optical component holders of the first interconnection layer **2100** can be secured to the base **102** of splice tray **100** by an adhesive, such as a piece of double sided tape or a transfer adhesive, or by engaging with first insert catches **131** disposed along the edges of interconnection area **130**. Similarly, optical component holders **350a** of the second interconnection layer **2200** can be either adhesively or mechanically secured to the detachable optical component riser **200**. Utilizing the detachable optical component riser allows for splice inserts to be stacked, essentially doubling the interconnection density (e.g. splice count) of the splice tray.

Exemplary optical component holders are used to secure/organize and/or identify the optical components stored therein. Conventional optical component holders may be made of a foam, an elastomer, a rubber or a plastic material which can be secured in splice tray by either an adhesive or by mechanical means. In one aspect, Optical component holders can be configured to hold individual mechanical splices such as 3M™ Fibrlok™ II Universal Optical Fiber Splice 2529 or 3M™ Fibrlok™ 250 μm Fiber Splice 2540 available from 3M company (St. Paul, Minn.), or individual fusion splices (2.4 mm fusion splices or 3 mm fusion splices) such as 3M™ Fiber Optic Splice Sleeve (3 mm sleeves) or 3M™ BPEO Fiber Optic Splice Sleeve (2.4 mm sleeves) also available from 3M company. In another aspect, Optical component holders can be configured to hold mass fusion splices or mass mechanical splices. Conventional optical component holders that are configured to hold fusion splices include 2.4 mm Single Fusion Splice Insert, 3.0 mm Single Fusion Splice Insert, 12RF Mass Fusion Splice Insert, each of which is available from 3M Company.

FIG. **6** shows the splice tray **100** and detachable optical component riser **200** used in the high-density splice tray **2000** of FIGS. **5A** and **5B** without the optical fiber ribbons **60**, ribbon fiber splice devices **90** and optical component

holders **350A**. Splice tray **100**, is the same splice tray as previously described in reference to FIG. **2A**.

Detachable optical component riser **200** can be a table-like structure comprising a generally rectangular surface panel **202** having a first end **202a** and a second end **202b** and four legs **204** extending from the support panel. Two legs extend from an edge of the support panel at the first end and two more of the legs extend from the edge of the support panel at its second end. A latch arm **205** is disposed between the legs at each end of the support panel to attach the optical component riser to splice tray **100**. The bottom edge of the latch arm **205** may include a barb (not shown) to improve the retention force of the optical component riser.

Splice tray **100** can include a plurality of sets of three slots **136a**, **136b** formed in a row in the width direction in interconnection area **130**. In each row of slots, there are two slots **136a** near each edge **132** of the interconnection area that are configured to receive the base of each leg **204** and a center slot **136b** that is configured to mate with the end of the latch arm **205** so secure the optical component riser to the splice tray. Having a plurality of sets of these slots enables the optical component riser to be placed at various points along the length of the splice tray or may permit the use of different sizes of optical component risers to be used in a single tray. For example, optical component riser **200** can hold four optical component holders while optical component riser **250** (FIGS. **1** and **7**) are configured to hold two optical component holders.

FIGS. **7** and **8A-8B** show one configuration of the modular, reconfigurable splice tray system having increase slack storage and optical fiber connector connectivity in splice tray **3000**. Rather than having a first interconnection layer as described previously with respect to FIGS. **5A-5B**, the area beneath optical component riser **250** can provide additional slack storage capacity in space **3100**. Optical component riser **250** is structurally similar to optical component riser **200** described previously.

Splice tray **3000** further includes a number of snap-in cable entry components **400**, **450**, **500** installed in cable entrances **105**, **106**. While splice tray **3000** includes one each of snap-in cable entry components **400**, **450**, **500**, the snap-in cable entry components can be mixed and matched depending on the needs of a particular application in the optical network. Additionally, any number of snap-in cable entry components may be used up to the number cable entrances in the splice tray.

A first embodiment of a snap-in cable entry components comprises an optical connector connection platform **400**. Detail views of optical connector connection platform **400** are provided in FIGS. **12A** and **12B**. Optical connector connection platform **400** has a flat top plate **402** having a first side **400a**, a second side **400b** and two opposing edges **400c**, **400d** extending between the first and second sides of the top plate. A first adapter bulkhead **410a** extends from the top surface **401** of flat plate **402** near edge **400c** and between the first and second sides of the top plate. A second adapter bulkhead **410b** extends from the bottom surface of flat plate **402** near edge **400d** and between the first and second sides of the top plate. The first and second bulkheads are structurally similar and will be referred to collectively as adapter bulkhead **410**.

Adapter bulkhead **410** comprises a generally rectangular open frame **411** having an adapter mounting plate **412** integrally formed on and covering a portion of one of the vertical faces of the open frame. The adapter mounting plate has at least one opening **413** to accept and hold a connector adapter **70**. The connector adapters can be selected from

simplex connector adapters (e.g. MPO connector adapters, SC connector adapters, etc.) or duplex connector adapters such as the LC connector adapters **70** shown in FIG. **12B**. The connector adapters are held in openings by positioning the adapter mounting plate **412** between the flange **57** and the spring clips **76** of the connector adapters.

In the exemplary embodiment shown in FIGS. **12A-12B**, each of the first and second adapter bulkheads **410a**, **410b** is configured to hold two connector adapters **70** providing a connection location for eight pairs of optical fiber connectors **80**, since the connector adapters shown in the figure are duplex connector adapters.

Optical connector connection platform **400** further includes four legs **403** extending from flat top plate **402** on a first side **400a** and a second side **400b** and near the corners of the top plate. A latch arm **405** extends from the flat top plate on each side between legs **403**. The latch arm has an outward facing barb **406** that is configured to lock into connection openings or slots **105b** in side walls **108** of splice tray **100** and slot **126** (FIG. **2B**) in side partition **125b** of receiving portion **120**. In an exemplary aspect, cable entrance **105** can include vertical guides **105c** disposed on the inside surface of sidewall **108** and **105d** formed on partition **125b** shown in FIGS. **2A** and **2B**. The vertical guides fit into grooves **404** formed in the legs **403** of the optical connector connection platform to align and stabilize the optical connector connection platform in the cable entrance providing fiber optic connector connectivity in the cable entrance **105** of splice tray **100**.

In an alternative embodiment, optical connector connection platform can include only a single adapter bulkhead extending from either the top or bottom surface of the optical connector connection platform's top plate.

A second embodiment of snap-in cable entry components comprises a cable tie down platform **450** disposed in cable entrance **105** to handle a larger number of optical fibers, buffer tube, cable sub groups or ribbon fibers entering the splice tray **3000**. Detail views of cable tie down platform **450** are provided in FIGS. **9A-9B**. Cable tie down platform **450** has a flat top plate **452** having a plurality of tie down points **452a** to strain relieve cables or buffer tubes **50** in a second layer entering and exiting the exemplary splice tray as shown in FIG. **9B**. The entering and exiting cables or buffer tubes can be secured to the tie down points by conventional cable ties (not shown). Cable tie down platform has four legs **453** extending from the flat top plate on a first side **450a** and a second side **450b** and near the corners of the top plate. A latch arm **455** extends from the flat top plate on each side between legs **453**. The latch arm has an outward facing barb **456** that is configured to lock into connection openings or slots **105b** in side walls **108** of splice tray **100** and **126** in side partition **125b** of receiving portion **120**. In an exemplary aspect, cable entrance **105** can include vertical guides **105c** disposed on the inside surface of sidewall **108** and **105d** formed on partition **125b**. The vertical guides fit into grooves **454** formed in the legs **453** of the cable tiedown platform to align and stabilize the cable tiedown platform in the cable entrance.

A third embodiment of snap-in cable entry components comprises a cable gripping platform **500**. Detail views of cable gripping platform **500** are provided in FIGS. **10A-10B**. Cable gripping platform **500** has a flat top plate **502** having a plurality of a plurality of gripping structures **507** formed on top of the top plate to strain relieve cables, zip tubes, or buffer tubes in a second layer entering and exiting the exemplary splice tray as shown in FIG. **10B**. In particular, FIG. **10B** shows a plurality of zip tubes **65** arranged in two

layers in cable entrance **106** of splice tray **100**. The first layer is disposed in gripping structures **107** on the base **102** of the tray, and the second layer is disposed in gripping structures **507** disposed in the top plate of the cable gripping platform.

Gripping structures **507** are substantially similar to gripping structures **107** described previously with respect to FIG. **2A**. Each gripping structure **507** comprises a pair of parallel wall sections **508**, **509** and a plurality of teeth or barbs **510** (shown in FIGS. **2A** and **11**) on the facing surfaces of the wall sections that will grip onto the surface of the cable, zip tube or buffer tube passing through the gripping devices. In an exemplary embodiment shown in FIG. **10A**, the pair of parallel wall sections comprise a long wall section **508** and a short wall section **509**. The long wall sections have a hold-down feature **511** formed at the top of an end of each long wall section that extend at least part way over a cable channel through the gripping device. The center long wall section has two hold-down features formed at the top of an end thereof extending at least part way over the cable channels on either side of the center long wall section. The hold-down features are configured to retain the cables, zip tubes, or buffer tubes in the gripping structure.

Cable gripping platform **500** has four legs **503** extending from flat top plate **502** on a first side **500a** and a second side **500b** and near the corners of the top plate. A latch arm **505** extends from the flat top plate on each side between legs **503**. The latch arm has an outward facing barb **506** that is configured to lock into connection openings or slots **106b** in side walls **108** of splice tray **100** and (not shown) in side partition **125b** of receiving portion **120**. In an exemplary aspect, cable entrance **106** can include vertical guides **106c** disposed on the inside surface of sidewall **108** and **106d** formed on partition **125b** shown in FIG. **2A**. The vertical guides fit into grooves **504** formed in the legs **503** of the cable gripping platform to align and stabilize the cable gripping platform in the cable entrance.

FIG. **11** shows how the use of the snap-in cable entry components, such as a cable tie down platform **450** can be used to create a hybrid cable entry. By providing a common base structure to the snap-in cable entry components and connection features in the cable entrances increases the flexibility of the cable entrances. For example, placing cable tie down platform **450** over the gripping structures **107** in cable entrance **106** different types of optical media can utilize the same cable entrance. Specifically, FIG. **11** shows that a plurality of zip tube can be disposed in a first layer in gripping structures **107** and a plurality of cables or buffer tubes can be secured to the top of the cable tie down platform in a second layer improving the flexibility of cable entrances of splice tray **100**.

FIG. **13** is an isometric view of a modular fiber optic connector connection device **300**. The fiber optic connector connection device comprises a flat base plate **302** having a first side **300a** and a second side and adapter bulkhead **310a** extends from the top surface **301** of flat plate **302** between the first and second sides of the base plate.

Adapter bulkhead **310** comprises a generally rectangular open frame **311** having an adapter mounting plate **312** integrally formed thereon and covering a portion of one of the vertical faces of the open frame. The adapter mounting plate has a plurality of openings **313** to accept and hold one or more connector adapters **70**. The connector adapters can be selected from simplex connector adapters or duplex connector as described previously. In the exemplary embodiments shown in FIGS. **7**, **13** and **14**, the modular fiber optic connector connection device **30** holds two connector adapters in each opening **313** by positioning the

adapter mounting plate 312 between the flange 57 and the spring clips 76 of the connector adapters. The number of connector adapters housed per opening as well as the number of openings can be altered to change the optical fiber connector connection density held within the splice tray.

Referring to FIGS. 7 and 13, modular fiber optic connector connection device 300 is designed to be housed within the interconnection area 130 of splice tray 100. The base plate of the fiber optic connector connection device further comprises latch arms 305 extending from the first and second sides of the baseplate. Each of the latch arms has an outward facing barb 306 that is configured to lock into slots (not shown) formed in the interconnection area of the base plate.

FIG. 14 is a fourth exemplary configuration of the modular, reconfigurable splice tray system in the form of a compact splice tray 4000. Interconnection connection tray 4000 comprises a compact splice tray 100'. The compact splice tray 100' comprises the same structural features as splice tray 100 described previously. The main difference between the splice tray 100 and the compact splice tray 100' shown in FIG. 14 is that the characteristic length,  $l$ , of the compact splice tray is smaller than the length,  $L$ , of splice tray 100 shown in FIG. 2A. Otherwise the splice trays are analogous allowing the use of any of the modular components described herein to be used with the splice tray 100. In the present embodiment, the compact splice tray comprises one optical component holder that is configured to hold six ribbon fiber splices 90 and an optical connector adapter holder 300 that is configured to connect sixteen optical fiber connector pairs.

FIG. 15 is a fifth exemplary configuration of the modular, reconfigurable splice tray system in the form of a first pivoting splice tray 5000. The first pivoting interconnection connection tray 5000 comprises a splice tray 100 having a plurality of optical component holders 350 disposed in interconnection area 130 of the splice tray, a first snap-on hinge component 600 attached to first receiving portion 120a disposed at a first end 103a of the splice tray and a latch component 550 attached to a second receiving portion 120b disposed at a second end 103b of the splice tray. Unless otherwise mentioned splice tray 100 described with respect to FIG. 2A and as such will not be further described here.

The first snap-on hinge component 600 enables splice trays 100a-100c to be pivotally mounted to a tray mount 800 that can be disposed in an enclosure (not shown) as shown in FIG. 19C. In this way tray 100a can be pivoted to an upright position so that the components inside splice tray 100b can be accessed.

Referring to FIGS. 16A-16C, first hinge component 600 comprises a pivot portion 600a and an anchor portion 600b disposed on opposite sides of a central support member 601. The pivot comprises plurality of legs 605 extending the central support member and each leg includes a first leg portion 605a and a second leg portion 605b. The first leg portion can be slightly shorter than the second leg portion. The first leg portion can have a pivot control projection 608 formed on the end thereof that is configured to engage with openings 830 formed in the tray mount to hold the splice tray in one or more predetermined positions. In the exemplary embodiment shown in FIG. 19C, slots 830 are configured to hold the splice tray in either an open or stacked condition. Note that splice tray 100a is shown in an open condition in FIG. 16C, while splice trays 100b, 100c are disposed in a stacked condition.

The second leg portion can have a pivot projection 607 formed near its end and extending outward from the cen-

terline of the hinge between leg portions 605b. In use, the pivot projection 607 of splice tray 100 is configured to engage with a pivot recess 820 in the tray mount 810 such that the splice tray can move between an open and a stacked condition. of second splice tray 100a disposed beneath it in the tray stack. The second leg portions may also include a flex control protrusion 604 near the free end of each leg portion. The flex control protrusion 604 prevents over bending of the second leg portions when being attached to or detached from the tray mount.

The anchor portion 600b of the first snap-on hinge component 600 comprises a pair of parallel stabilizing struts 620 and a pair of locking arms 625. The stabilizing struts and the locking arms can be inserted into connection bays 125 of receiving portion 120a between partition walls 125a, 125b. When inserted, stabilizing strut 620 is disposed against partition 125b and the base 102 of splice tray 100 and the locking arm is disposed against partition 125a. Brace 128 ensures that the stabilizing strut in the proper position. A hooked end 626 on the end of the locking arm engages with slot 127 in partition 125a to lock the first snap-on hinge component 600 to splice tray 100. The anchor portion can further include a support tab 602 that fits into frame portion 121 to further stabilize the connection of the first snap-on hinge component to splice tray 100.

FIGS. 15, 17A-17B, show a latch component 550 that can be attached to a receiving portion disposed at an end of splice tray 100. Latch component 550 comprises an anchor portion 550b, a wall portion 565 and a latch portion 560.

The anchor portion 550b of the latch component 550 comprises a pair of parallel stabilizing struts 570 and a pair of locking arms 575. The stabilizing struts and the locking arms can be inserted into connection bays 125 of receiving portion 120b between partition walls 125a, 125b. When inserted, stabilizing strut 570 is disposed against partition 125b and the base 102 of splice tray 100 and the locking arm is disposed against partition 125a. Brace 128 ensures that the stabilizing strut in the proper position. A hooked end 576 on the end of the locking arm engages with slot 127 in partition 125a to lock the latch component 550 to splice tray 100. The anchor portion can further include a support tab 552 that fits into frame portion 121 to further stabilize the connection of the latch component to splice tray 100.

Wall portion 555 extends laterally from anchor portion 550b and is configured to close an end of the splice tray (i.e. second end 103b in FIGS. 15 and 17b).

Latch portion 560 is attached to the anchor portion 550b and comprises a body portion 562 having a recess 563 formed in a top surface thereof and a catch portion 565. The recess forms a slot between the recess 563 and the frame portion 121 of receiving portion when attached to the receiving portion of splice tray 100. For example, catch 565b of latch component 550b of splice tray 100b can engage with the slot formed by recess 563c and frame portion 121c of splice tray 100c to secure the second ends 103b of splice trays 100a and 100b together as shown in FIG. 17B. The catch 565c of latch component 550c is shown as being engaged with a slot 842 in a hasp 840 of tray mount 800.

In an alternative embodiment, the wall portions can be removed from the modular latch component as shown in FIGS. 21A and 21B and be replaced by arched fiber guide portions 700 that can be fitted into the cable entrances 106 of splice tray 100. The arched fiber guide portions can have a hollow three-dimensional shape configured to fit into the cable entrances of splice tray 100. A arched fiber guide portions can have alignment grooves 704 and a pair of latch

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arm **705** disposed on opposite sides of the fiber guide portion that are configured to secure the fiber guide portion into a cable entrance. For example, latch arm **705** has an outward facing barb that is configured to lock into connection openings or slots **106b** in side walls **108** of splice tray **100** and a slot (not shown) in side partition **125b** of receiving portion **120**. Vertical guides **106c**, **106d** fit into the grooves in the fiber guide portion to align and stabilize fiber guide platform in the cable entrance **106**.

While FIGS. **15-17B** show the first snap-on hinge component **600** attached to the first receiving portion at the first end of splice tray **100** and the latch component attached to the second receiving portion at the second end of the splice tray, it should be recognized that this is an arbitrary assignment since the first and second receiving portions have analogous structures and either component may be secured to either end of the splice tray in a similar manner to that described above.

FIG. **18** is a partially exploded view of a sixth exemplary configuration of the modular, reconfigurable splice tray system in the form of a second pivoting splice tray **6000**. The second pivoting interconnection connection tray **6000** comprises a splice tray **100** having a plurality of optical component holders **350** disposed in interconnection area **130** of the splice tray, a second snap-on hinge component **650** attached to first receiving portion **120a** disposed at a first end **103a** of the splice tray and a latch component **550** attached to a second receiving portion **120b** disposed at a second end **103b** of the splice tray. Unless otherwise mentioned splice tray **100** described with respect to FIG. **2A** and as such will not be further described here.

The second snap-on hinge component **650** enables a splice trays **100** to be pivotally mounted to a second splice tray **100** beneath it by a hinging mechanism disposed at the first end **103a** of the base **102** as shown in FIG. **19B**.

Referring to FIGS. **19A** and **19B**, second hinge component **650** comprises a pivot portion **650a** and an anchor portion **650b** disposed on opposite sides of a central support member **651**. The pivot comprises plurality of legs **655** extending the central support member and each leg includes a first leg portion **655a** and a second leg portion **655b**. The first leg portion can be slightly longer than the second leg portion allowing the trays to be offset from one another in a stepped arrangement when stacked, thus permitting free access to the second splice tray **100a** when splice tray **100** is rotated to an open position. The first leg portion can have a pivot recess **656** formed on the end thereof and the second leg portion can have a pivot projection **657** formed near its end. In use the pivot projection **657** of splice tray **100** is configured to engage with a pivot recess **656A** of second splice tray **100a** disposed beneath it in the tray stack.

The anchor portion **650b** of the second snap-on hinge component **650** comprises a pair of parallel stabilizing struts **670** and a pair of locking arms **675**. The stabilizing struts and the locking arms can be inserted into connection bays **125** of receiving portion **120a** between partition walls **125a**, **125b**. When inserted, stabilizing strut **670** is disposed against partition **125b** and the base **102** of splice tray **100** and the locking arm is disposed against partition **125a**. A brace **128** (FIG. **2B**) ensures that the stabilizing strut in the proper position. A hooked end **676** on the end of the locking arm engages with slot **127** in partition **125a** to lock the second snap-on hinge component **650** to splice tray **100**. The anchor portion can further include a support tab **652** that fits into frame portion **121** to further stabilize the connection of the second snap-on hinge component to splice tray **100**.

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FIGS. **20A-20C** illustrate another way of securing the exemplary interconnection systems of the present invention into an enclosure **7000**. For the sake of simplicity, the interconnection system is represented by splice tray **100** in these figures. FIG. **20A** shows the base **7100** of enclosure **7000** having the splice tray of the exemplary interconnection system disposed therein without the need of a splice tray platform **1050** shown in FIG. **4** or the tray mount **800** shown in FIG. **16C**. Instead splice tray **100** is secured in the base of the enclosure by modular, stackable tray supports **900**. FIG. **20B** is a sectional view of enclosure **7000**. Enclosure **7000** comprises a base **7100** and a cover **7200** that can be secured to the base to provide a protected interior space. The enclosure will include some number of cable ports to allow cables to enter and exit the protected space. In enclosure **7000**, the cable ports are formed when port portions, such as port portions **7120** shown in FIG. **20A**, in the base and the cover are brought together. The protected space within the enclosure is used to store slack fiber/cable and to interconnect fibers from a plurality of cables (not shown). One advantage of the high-density interconnection structures of the present invention is that a plurality of splice trays can be reduced to a single splice tray providing additional room to store slack.

The modular, stackable tray supports **900** shown in FIGS. **20B** and **20C** can provide additional flexibility on how the splice trays are stored within the enclosure. If additional slack storage is needed the tray supports can be stacked to provide more space below the splice tray. If less slack is required, but more trays, a single tray support can be used to maximize the number of splice trays that can be housed in the enclosure. Additionally, using the modular tray supports can allow positioning of the splice trays to minimize interference with the cable ports.

Tray supports **900** have a body **910** and a plurality of tapered legs **915** that engage with recessed portion **920** in the body of another of the tray supports. Openings can be formed through the body to locking a stack of tray supports together with a cable tie **95** (FIG. **20B**). Splice tray **100** can be secured to the top tray support in a stack of tray supports by one or more mechanical fasteners, e.g. screws **5**, inserted through holes **160** in the base **103** of the splice tray and pass into threaded receptacle **930** integrally formed with the body of the tray supports.

The modular, reconfigurable splice tray system described herein is a highly configurable splice tray system that can allow the craftsman greater flexibility to design an splice tray or system that can meet diverse network design requirements with a common set of modular accessories. The exemplary splice tray of the exemplary modular, reconfigurable splice tray system can be combined with a wide range of modular components to change not only the configuration of the splice tray, but the application space where the splice tray can be used. The same base splice tray can be used in both inline applications as well as in butt-style configurations.

The modular, reconfigurable splice tray system can be used for splicing ribbon and/or discrete fiber using snap-in stackable cable entry devices. The style of the cable entry region of a splice tray can be changed by utilizing snap-in cable entry components. In some embodiments the snap-in cable entry components allow multi-level fiber entry attach points. While in other embodiments, the snap-in cable entry components can be used to mount fiber optic connector adaptors enabling optical fiber connector connections in the cable entry region of the splice tray.

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Additionally, the exemplary splice tray trays described herein can be attached together in a side-by-side configuration to create a larger tray having multiple compartments. The wall between adjacent compartments include removable partitions for fibers to pass between adjacent compartments. Tray expansion features are self-mating and require no additional parts.

The modular, reconfigurable splice tray system includes additional snap-in modular components to increase the trays splice density using a removable splice insert riser. In another aspect, the removable splice insert riser can be removed from the splice tray during the splicing and reinstalled in the tray afterwards. In some applications, the space under the insert riser can be used to manage and store the ribbon fiber.

The present invention should not be considered limited to the particular examples described above, but rather should be understood to cover all aspects of the invention as fairly set out in the attached claims. Various modifications, equivalent processes, as well as numerous structures to which the present invention may be applicable will be readily apparent to those of skill in the art to which the present invention is directed upon review of the present specification. The claims are intended to cover such modifications and devices.

The invention claimed is:

1. A modular, reconfigurable splice tray system, comprising:

a splice tray having a base, a pair of side walls extending longitudinally from a first end to a second end of the base, and a plurality of cable entrances formed at the first end and the second end of the base, and

at least one modular component comprising a plurality of snap-in cable entry components to allow multi-level fiber entry attach points,

wherein each side wall includes tray connection features that are configured to connect two splice trays together in a side-by-side configuration, and wherein the number of snap-in cable entry used in the system is up to the number of cable entrances in the splice tray; and

wherein the at least one of the plurality of snap-in cable entry components comprises a top plate having a first side and a second side, a plurality of legs extending from the first side and the second side of the top plate, and a latch arm disposed between the plurality of legs on the first side and the second side of the top plate.

2. The system of claim 1, wherein the tray connection features comprise at least one of a latching protrusion, a dovetail depression, a latch, and a dovetail locking element.

3. The system of claim 1, wherein the at least one modular component is an optical connector connection platform having an adapter bulkhead that is configured to hold a plurality of connector adapters.

4. The system of claim 1, wherein the at least one modular component is a cable tie down platform that has a plurality of tie down points formed in the surface of the top plate to provide strain relief cables or buffer tubes entering and exiting the splice tray.

5. The system of claim 1, wherein the at least one modular component is a cable gripping platform that has a plurality of gripping structures formed on the top plate to strain relieve cables, zip tubes, or buffer tubes in a second layer entering and exiting the splice tray.

6. The system of claim 1, wherein the splice tray further comprises a first interconnection layer disposed on the base, and a second interconnection layer positioned over at least a portion of the first interconnection layer, wherein the

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second interconnection layer is disposed on a removable optical component riser that can be attached to the base at a plurality of locations.

7. The system of claim 1, further comprising at least one optical component holder disposed in the splice tray.

8. The system of claim 6, further comprising at least one optical component holder disposed on the removable optical component riser.

9. The system of claim 8, wherein the at least one optical component holder is configured to hold a plurality of optical components selected from the group consisting of optical splitters, mass fusion splices, single fusion splices, multifiber mechanical splices and mechanical splices.

10. The system of claim 1, wherein the at least one modular component is a hinge component that attaches to a receiving portion of the splice tray.

11. The system of claim 1, wherein the at least one modular component is a latch component that attaches to a receiving portion of the splice tray.

12. The system of claim 1, wherein the at least one modular component is an optical fiber connector adapter holder that is connected to the base of the splice tray between the first end and the second end of the base.

13. A modular, reconfigurable splice tray system, comprising:

a splice tray having a base, a pair of side walls extending longitudinally from a first end to a second end of the base, and a plurality of cable entrances formed at the first end and the second end of the base, and

at least one modular component comprising a plurality of snap-in cable entry components to allow multi-level fiber entry attach points,

wherein each side wall includes tray connection features that are configured to connect two splice trays together in a side-by-side configuration, and wherein the number of snap-in cable entry used in the system is up to the number of cable entrances in the splice tray, and

wherein the splice tray further comprises a first interconnection layer disposed on the base, and a second interconnection layer positioned over at least a portion of the first interconnection layer, wherein the second interconnection layer is disposed on a removable optical component riser that can be attached to the base at a plurality of locations.

14. The system of claim 13, wherein the tray connection features comprise at least one of a latching protrusion, a dovetail depression, a latch, and a dovetail locking element.

15. The system of claim 13, further comprising at least one optical component holder disposed in the splice tray.

16. The system of claim 13, further comprising at least one optical component holder disposed on the removable optical component riser.

17. The system of claim 15, wherein the at least one optical component holder is configured to hold a plurality of optical components selected from the group consisting of optical splitters, mass fusion splices, single fusion splices, multifiber mechanical splices and mechanical splices.

18. The system of claim 13, wherein the at least one modular component is a latch component that attaches to a receiving portion of the splice tray.

19. A modular, reconfigurable splice tray system, comprising:

a splice tray having a base, a pair of side walls extending longitudinally from a first end to a second end of the base, and a plurality of cable entrances formed at the first end and the second end of the base, and

at least one modular component comprising a plurality of  
snap-in cable entry components to allow multi-level  
fiber entry attach points,  
wherein each side wall includes tray connection features  
that are configured to connect two splice trays together 5  
in a side-by-side configuration, and wherein the num-  
ber of snap-in cable entry used in the system is up to the  
number of cable entrances in the splice tray, and  
wherein the at least one modular component is a hinge  
component that attaches to a receiving portion of the 10  
splice tray.

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